# AMERICAN GAS JOURNAL

MAY, 1938



*With*

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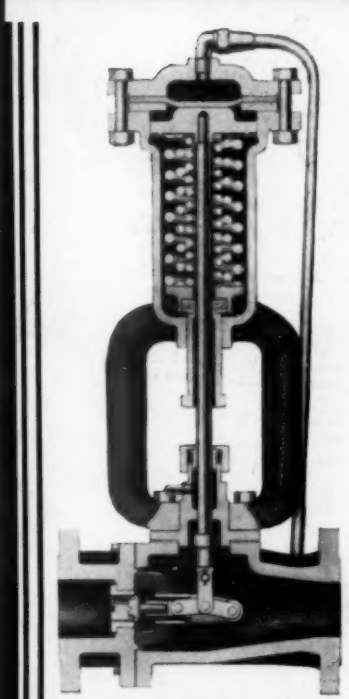

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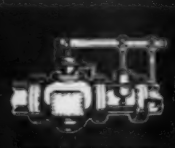
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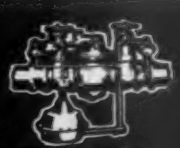
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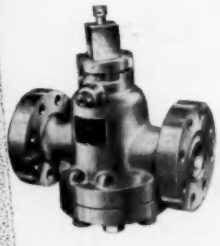

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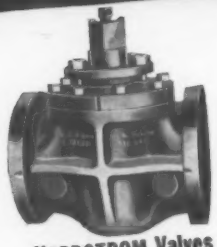

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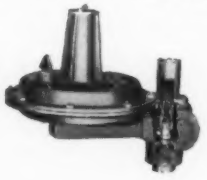

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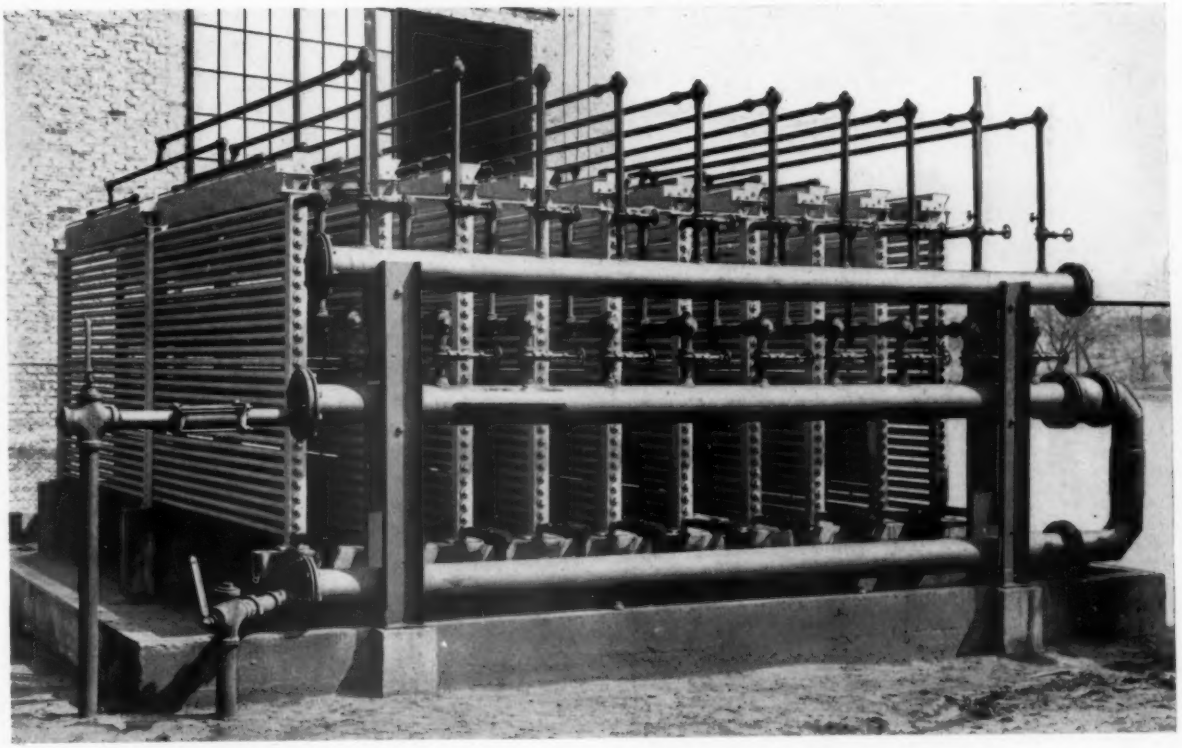

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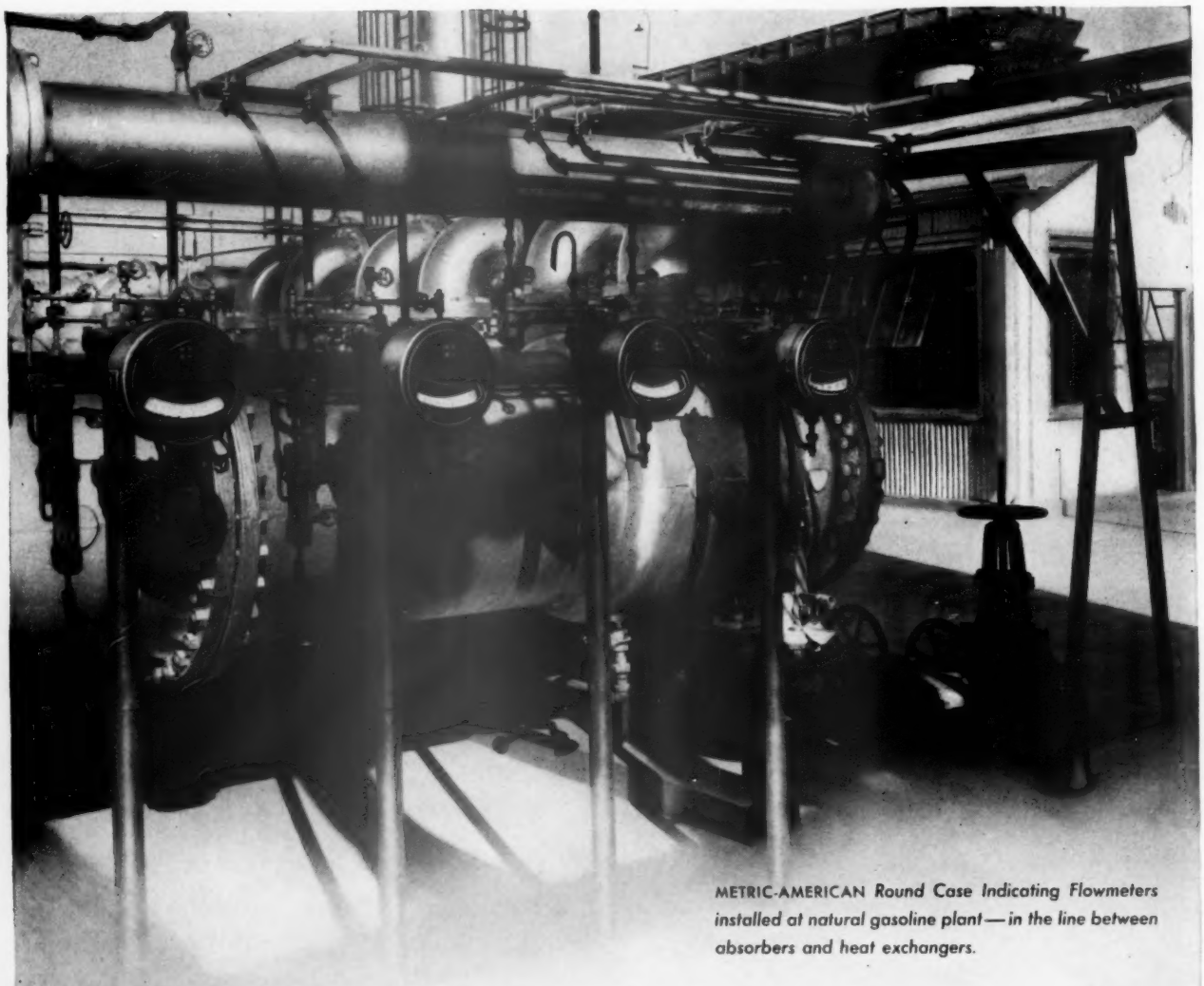

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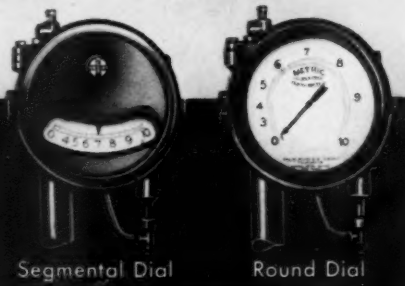

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MAY
1938

AMERICAN
GAS JOURNAL

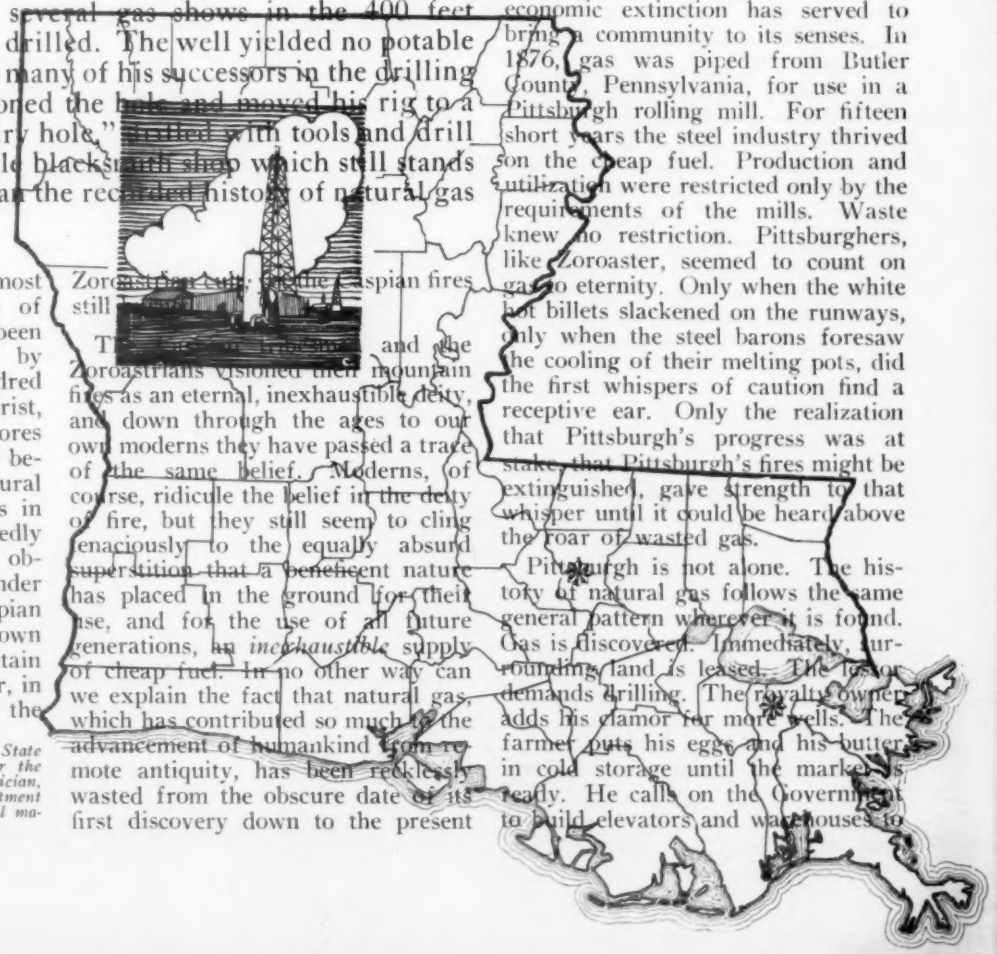
VOLUME 148
No. 5

# Natural Gas in Louisiana

by

W. F. Chisholm*

THE first chapter in the romantic history of natural gas in Louisiana begins with a picture of fifteen husky negro slaves laboriously toiling under a crude tripod on the banks of Cane River at Bermuda, ten miles south of Natchitoches. In 1821, P. Phanor Prudhomme, an early settler of the hardy French stock which wrested the greater part of Central Louisiana from the wilderness, started building his plantation home, and began drilling for water to meet his needs. The log of his first well recorded several gas shows in the 400 feet through which the well was drilled. The well yielded no potable water, however, and, like so many of his successors in the drilling game, Prudhomme "abandoned the hole and moved his rig to a new location." With his "dry hole," [illegible] with tools and drill stem hand-forged in the little blacksmith shop which still stands at the old well location, began the recorded history of natural gas in Louisiana.



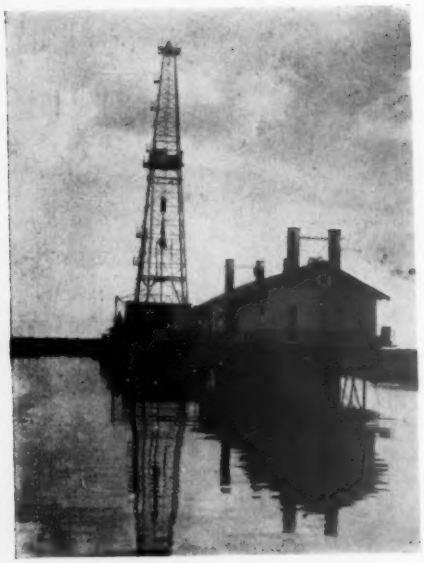
Crude oil and natural gas, to most of us only accepted amenities of modern civilization, have been known, produced and utilized by many ancient peoples. Six hundred years before the coming of Christ, the tribes who lived on the shores of the Caspian and Euxine Seas beheld the flames of burning natural gas belching forth from fissures in the mountainside. These supposedly eternal fires became to them an object of worship. The Parsees under Zoroaster subjugated the Caspian tribesmen and adopted as their own idea the deification of the mountain fires. Twelve hundred years later, in 624 A.D., Heraclius wiped out the Zoroastrian cult, but the Caspian fires still [illegible]

[illegible] and the Zoroastrians visioned their mountain fires as an eternal, inexhaustible deity, and down through the ages to our own moderns they have passed a trace of the same belief. Moderns, of course, ridicule the belief in the deity of fire, but they still seem to cling tenaciously to the equally absurd superstition that a beneficent nature has placed in the ground for their use, and for the use of all future generations, an *inexhaustible* supply of cheap fuel. In no other way can we explain the fact that natural gas, which has contributed so much to the advancement of humankind from remote antiquity, has been recklessly wasted from the obscure date of its first discovery down to the present day. Centuries of reckless waste, centuries of forgotten fields, have failed to wipe out the foolhardy notion of inexhaustibility.

Under the benign influence of nature's finest fuel, many a country trading post has grown to a thriving industrial center. Natural gas made Pittsburgh, made the great industrial centers of Ohio and Indiana, yet here and there only a threat of economic extinction has served to bring a community to its senses. In 1876, gas was piped from Butler County, Pennsylvania, for use in a Pittsburgh rolling mill. For fifteen short years the steel industry thrived on the cheap fuel. Production and utilization were restricted only by the requirements of the mills. Waste knew no restriction. Pittsburghers, like Zoroaster, seemed to count on gas to eternity. Only when the white hot billets slackened on the runways, only when the steel barons foresaw the cooling of their melting pots, did the first whispers of caution find a receptive ear. Only the realization that Pittsburgh's progress was at stake, that Pittsburgh's fires might be extinguished, gave strength to that whisper until it could be heard above the roar of wasted gas.

Pittsburgh is not alone. The history of natural gas follows the same general pattern wherever it is found. Gas is discovered. Immediately, surrounding land is leased. The lessor demands drilling. The royalty owner adds his clamor for more wells. The farmer puts his eggs and his butter in cold storage until the market is ready. He calls on the Government to build elevators and warehouses to

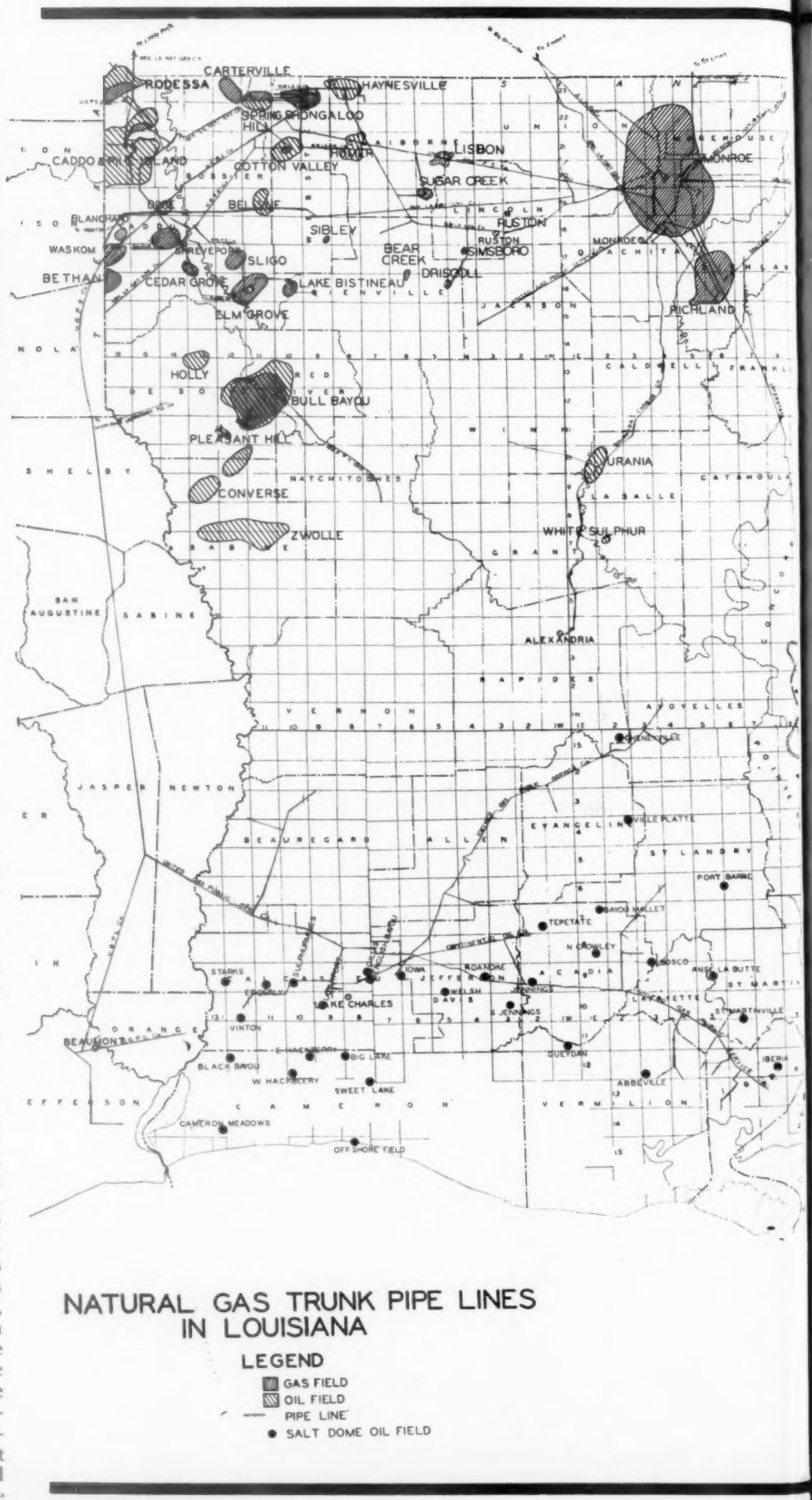
* *Engineer, Department of Conservation, State of Louisiana. Acknowledgment is made for the valuable assistance of C. P. Dunbar, statistician, and D. E. Fuellhart, engineer, of the Department of Conservation, for preparation of statistical material, maps and illustrations.*



One of The Texas Co's drilling wells in Fafitte Field, Jefferson Parish, Louisiana showing barge type of drilling rig. Derrick and power plant are mounted on barges and the barges are sunk to the canal bottom. After completion, the equipment is refloated and moved to another location. Canals are dredged cut to each location as the field develops. Lafitte, one of the most prolific oil fields in the Coastal area, furnished six million cubic feet of gas per day for operation of a sulphur plant 75 miles below New Orleans.

store his grain. He calls on the banks and the Government for loans to carry him over a poor cotton market while he stores his cotton. He favors erection of huge dams to hold back flood waters until he can use the water to good advantage,—and undoubtedly he is right. He calls on the gas producer to produce now! He does not seem to realize that gas can be stored efficiently only in its original reservoir. Lessors of gas lands demand that the path of the producer follow the vicious circle of over-development; regardless of market conditions, each gas well must have its offset, and each offset its offset, until the field is defined. Even in those rare instances where lessors and lessees can agree on orderly production, the vast army of royalty holders demands immediate returns.

Under these conditions, conditions for which the much abused producers are not alone to blame; conditions, the blame for which rests equally on the shoulders of the producer, the royalty trader, the lessor, and the public; conditions for which the established system of leasing is largely responsible,—under these conditions, it is not to be marvelled at that the history of almost every gas field that has come into being may be




## NATURAL GAS TRUNK PIPE LINES IN LOUISIANA

LEGEND

- GAS FIELD
- OIL FIELD
- PIPE LINE
- SALT DOME OIL FIELD

Drill stem and bits used in 1821 to drill 400 foot hole at Bermuda, Natchitoches Parish, Louisiana, by P. Phanor Prudhomme. These tools were all hand forged on location by old Solomon, a six foot negro slave skilled in the smithy's art. Drilling round hole, squaring up the hole, and setting cypress plank casing, Prudhomme, with 15 negro slaves as his power plant, was unable to get through hard rock at 400 ft., and abandoned hole. The well was drilled for water, but found several gas shows

summed up under one typical outline,—discovery, over-trading, over-development, rapid and wasteful depletion of reserves, and,—death by drowning! Into this picture, as a last resort, must come the power of the state, the owner of the gas until it is reduced to possession. Through its police power, the state, by wise regulation, can break the vicious circle.

The history of Louisiana's natural gas is not unlike the history of gas wherever it has been discovered. In Louisiana, gas waste and the fight against gas waste began when old Solomon, Prudhomme's towering negro blacksmith hammered out his first drilling bit on the old Bermuda plantation. Prudhomme, and his drilling crew of negro slaves, saw in the gas only an obstacle to be overcome in their search for water. The discovery of oil at Spindletop brought a rush of drillers to the Southwest, and the Heywood brothers brought in Louisiana's first oil well near Jennings in 1901. This discovery led to widespread search for oil within the state. In May, 1905, Louisiana's first known gas in commercial quantities was developed in the Caddo Field north of Shreveport. Just as Phanor Prudhomme deemed his gas a hindrance to the production of water, so many of the early prospectors in

North Louisiana saw in their gas only a hindrance to the production of oil. There was no market for the gas, but there was a deeply rooted idea that blowing of the gas into the air would cause the well to "go to oil." How great was the total of the gas blown into the air in those early days will never be known,—known only is the fact that it took many years of blind waste to convince even conservative operators that wells blow not into oil, but into salt water. Not until about 1917 were the people of Louisiana sufficiently aroused to the danger of gas waste to take the first real steps toward the protection of their greatest natural gift.

The impetus needed for the development of public interest and legislative action, arose from the realization that in the Monroe Gas Field,

Hook-up on Woodley Petroleum Co.'s Gray B-4, Cotton Valley Field, Webster Parish, Louisiana, wellhead on right, hot water heater, built around choke, on left, producing from the Bodcau Sand, below 8000 feet. Bodcau Sand wells are drilled on 80 acre spacing, have open flow capacities of approximately 200,000,000 cubic feet per day, with bottom hole pressures of about 4000 lbs., and gas/oil ratios varying from 12000/1 to 15000/1. In order to conserve the gas, production of oil is limited by the market demand for the gas. No gas is blown into the air except during operating emergencies. It costs $125,000 to drill these wells. It costs $165,000 to kill one that got loose.

Louisiana possessed the world's greatest gas reserve known at that time. In September, 1916, Louis Locke, a Rumanian emigrant who had worked in his youth in the oil fields of his native country, brought in the first commercial well in the Monroe Field. The subsequent drilling and rapid development of the field into a great potential reservoir of cheap fuel, soon built up an available capacity far in excess of market demand, attracted the carbon black producers from West Virginia, and began an orgy of unrestricted drilling and production. The field provided, however, a great laboratory for the state, and alarming drops in closed pressure with more alarming water encroachment served to focus the attention of the state legislature on the problem. More stringent laws were passed. Allowable withdrawals were limited to a percentage of the measured open-flow capacity of the well. Like all restrictions based on "per well allowables" alone this led to greater density of drilling and failed to solve the difficulty. In 1924, however, a practical solution was found in the gas conservation act passed by the legislature. For the first time, the amount of acreage drained by a well became the deciding factor in the size of its allowable withdrawal. In Act 252 of 1924, Louisiana presented to the gas industry the idea of the acreage factor as a controlling influence in volume of production. Since that time Louisiana has had no major difficulty in the maintenance of orderly development in its gas fields.

The conservation of gas in *gas fields* is, however, only a part of the problem of gas conservation. The

**Domestic, Commercial, Industrial Natural Gas Consumption in Louisiana — 1935**

| | |
|---|---|
| *Domestic* | |
| Number Domestic Consumers | 140,540 |
| Domestic Consumption in Cubic Feet | 6,842,000,000 |
| Total Value at Points of Consumption in Dollars | $4,860,000 |
| Average Value in Cents per M at Point of Consumption | 71.0 |
| *Commercial* | |
| Number Commercial Consumers | 17,140 |
| Commercial Consumption in Cubic Feet | 4,171,000,000 |
| Total Value at Points of Consumption in Dollars | $1,551,000 |
| Average Value in Cents per M at Point of Consumption | 37.2 |
| *Industrial* | |
| Total Industrial Consumption in Cubic Feet | 140,921,000,000 |
| Total Value at Point of Consumption in Dollars | $9,990,000 |
| Average Value in Cents per M at Point of Consumption | 7.1 |

*Source: Minerals Yearbook, 1937.*

**Natural Gas Industry in the United States 1936-1937**

| | 1937 | 1936 | % Change |
|---|---|---|---|
| *CUSTOMERS:* | | | |
| Domestic (Including House Heating) | 6,502,000 | 6,277,000 | + 3.6 |
| Commercial | 502,000 | 487,000 | + 3.1 |
| Industrial | 42,000 | 37,000 | + 13.5 |
| Total | 7,046,000 | 6,801,000 | + 3.6 |
| *GAS SALES (M Cubic Feet)* | | | |
| Domestic (Including House Heating) | 362,021,000 | 343,473,000 | + 5.4 |
| Commercial | 103,933,000 | 97,590,000 | + 6.5 |
| Industrial | 870,909,000 | 789,582,000 | + 10.3 |
| Total | 1,336,863,000 | 1,230,645,000 | + 8.6 |
| *REVENUE (Dollars)* | | | |
| Domestic (Including House Heating) | $246,932,000 | $236,979,000 | + 4.2 |
| Commercial | 48,251,000 | 46,306,000 | + 4.2 |
| Industrial | 145,993,000 | 129,426,000 | + 12.8 |
| Total | $441,176,000 | $412,711,000 | + 6.9 |

*American Gas Association Monthly, January, 1938, pp. 3-4, 1938.*

waste of gas in *oil fields* has always been a cardinal sin of the oil industry, and only through bitter experience has Louisiana, like all of the oil producing states, finally learned that this conservation of natural gas in the production of crude oil is by far the greater and more difficult phase of the problem. The clash of selfish interests, the feverish demand for quick returns, the reckless line fighting that characterize most oil development under our present leasing system, have been the bane of the industry since the days of Colonel Drake. No one knows, no human mind is capable of estimating the tremendous waste of natural gas in the production of crude oil.

Section of 22" coated pipe line of Mississippi River Fuel Corporation from Monroe Field to St. Louis. Grading the ditch prior to lowering pipe.

*Photo courtesy Wailes-Dove-Hermiston Corp'n.*

Late in 1922, the shallow Cotton Valley Field in Webster Parish came in with its discovery well making 30,000,000 cubic feet of gas per day. Subsequent drilling gave evidence of a reserve approximating 100 billion cubic feet. After completion of six successful gas wells, one enterprising company laid a line into the field in 1923. A well on the edge of the field was then brought in making 150 barrels of oil with 30 million cubic feet of gas. Immediately the lid blew off Cotton Valley. Two hundred wells were completed within a year, practically all of them saving only a small amount of oil at the expense of the waste of a large amount of gas. One short year after the gas line was laid to the field to pipe Cotton Valley's gas to the market, there was not enough pressure left in the field to buck the line pressure, nor enough gas left in the field to feed the boilers of drilling wells. Flow in the line was reversed, and Cotton Valley boilers were fired with gas from other fields. Of the estimated 100 billion cubic feet, less than one billion was piped out of the field to market. The original gas reserve represented approximately $4,000,000. The gas recovered and piped out represented less than $40,000. In other words, in the early life of the field, nearly four million dollars in gas was wasted to recover only about eight and a half million dollars in oil. How much oil was lost in dissipation of reservoir pressure, oil lost in addition to the gas, cannot well be estimated. The lesson of Cotton Valley teaches that the blowing off of gas to accomplish a pitifully small increase in "flush" production means unwarranted increase in lifting costs, short life, unjustifiable waste of gas, and an inexcusable increase in the percentage of unrecoverable oil. The history of the Glen Rose production in the Pine Island Field, the Leeville Field in the Gulf Coast, and most of the earlier fields bears out the same lesson.

The El Dorado and Smackover Fields in Arkansas, Seminole and the City Field in Oklahoma, the ridiculous scramble in the early life of the East Texas Field, even the present situation in East Texas of leg-to-leg derrick locations in the face of falling per-well allowables should have convinced the industry that it is time to call a halt to gas waste in oil production.

In her oil conservation act of 1936, Louisiana served notice that within her borders such waste would no longer be countenanced. The acreage allowable factor that has meant so much in orderly development of Louisiana gas fields was extended to oil field control. Pooling of small tracts was encouraged. The first major de-

**Summary of North Louisiana Natural Gas Fields in 1937**

| | |
|---|---|
| Number of Gas Wells Completed | 102 |
| Number of Wells Capable of Producing Gas | 1,339 |
| Total Daily Open Flow Capacity of Wells in Cubic Feet (Feb. 1938) | 8,503,351,000 |
| Natural Gas Production for Year 1937 in Cubic Feet | 298,267,935,000 |
| Natural Gas Production for December, 1937, in Cubic Feet | 24,546,942,000 |
| Natural Gas Burned Into Carbon Black, in Cubic Feet | 39,186,564,000 |
| Natural Gas Run Into Pipe Lines in 1937, in Cubic Feet | 238,966,669,000 |

*Source: Louisiana Department of Conservation.*

Continental Oil Co.'s Gasoline Plant, English Bayou Field, Calcasieu Parish.

United Gas Pipe Line Company's gasoline plant, Cotton Valley Field, Webster Parish.

velopment under the 1936 law went into effect on January 1, 1937, when almost overnight a 700,000,000 cubic feet daily waste of gas was reduced to approximately 20,000,000 cubic feet. Louisiana is sold on the idea that gas can be saved in oil fields, and that the saving of oil field gas means increase in the percentage of recoverable oil.

Reference to the accompanying map will reveal that Louisiana's productive fields may be grouped into three general areas, the Sabine Uplift area centering around Shreveport in the northwestern part of the state, the Monroe-Richland-Epps gas area in the northeast, and the Gulf Coastal salt dome area along the Gulf shore. Gas production in commercial quantities, with few exceptions has been limited to the two northern areas.

Only recent development has tended to link up these two northern sections through the discovery of the relatively undeveloped gas fields at Dubberly (Sibley), Simmsboro, Driscoll and Bear Creek. The Northeastern area is still confined to gas production only,—from the Monroe, Richland, and Epps fields. The Urania Field, producing from the Cane River Sand and the small White Sulphur Springs field which has produced small amounts of oil, from the Jackson-Lufkin contact, are minor exceptions.

Gulf Coast Salt Dome production yielded no true gas fields except the old Houma Field, near the new Lirette Oil Field in Terrebonne Parish. At the present time some relatively small amounts of gas are picked up by the pipe lines from several of the domes, but with the exception of Tepetate and Lafitte the commercial production of gas is relatively unimportant. Tepetate feeds a pipe line providing gas for the Mathieson Chemical plant at Lake Charles, and Lafitte provides gas for the operation

**Natural Gas Produced in Louisiana and United States — 1927 - 1937**

| | Louisiana Natural Gas Production in Millions Cubic Feet | United States Natural Gas Production in Millions Cubic Feet | Average Value at Point of Consumption in Cents per M Cubic Feet | Louisiana Production as a per cent of U. S. |
|---|---|---|---|---|
| 1927 | 186,961 | 1,445,428 | 22.0 | 12.8 |
| 1928 | 227,821 | 1,568,139 | 23.2 | 14.5 |
| 1929 | 261,138 | 1,917,693 | 21.6 | 13.6 |
| 1930 | 278,341 | 1,943,421 | 21.4 | 14.3 |
| 1931 | 224,155 | 1,686,436 | 23.3 | 13.2 |
| 1932 | 201,561 | 1,555,990 | 24.7 | 12.9 |
| 1933 | 197,826 | 1,555,474 | 23.7 | 12.7 |
| 1934 | 225,713 | 1,770,721 | 22.3 | 12.7 |
| 1935 | 249,450 | 1,916,595 | 22.4 | 13.0 |
| 1936 | 283,813*** | 2,175,000** | | 13.0**** |
| 1937 | 301,147*** | 2,500,000** | | 12.0**** |

*Source: Minerals Yearbook, 1937.*
** Includes only gas delivered to consumers.*
*** Estimate of H. J. Struth, Am. Gas Association Monthly, February, 1938.*
**** Metered production of natural gas as reported by Louisiana Department of Conservation.*
***** Estimate.*

**Natural Gasoline Produced in Louisiana and United States 1927-1937**
**(In thousands of gallons)**

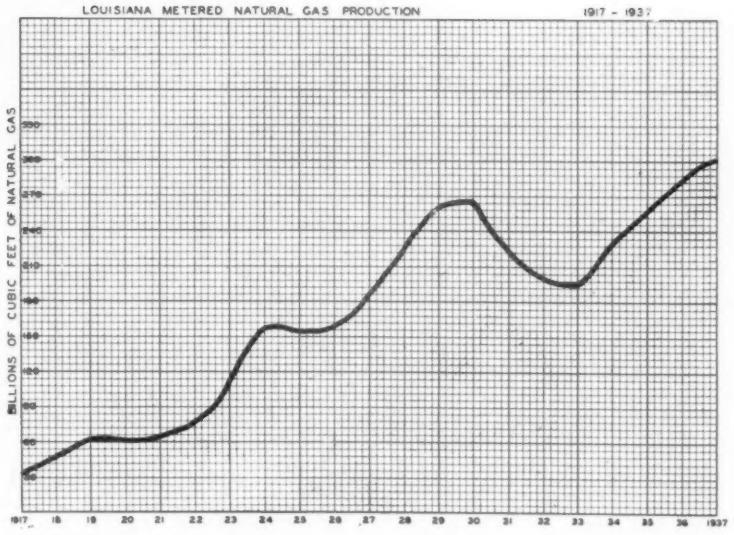
| | Louisiana Natural Gasoline Production | United States Natural Gasoline Production | Average Value at Plant in Cents per Gallon | Louisiana Production as per cent of U. S. Production |
|---|---|---|---|---|
| 1927 | 44,844 | 1,641,144 | 7.2 | 2.7 |
| 1928 | 55,022 | 1,814,034 | 7.7 | 3.0 |
| 1929 | 64,957 | 2,233,688 | 7.1 | 2.9 |
| 1930 | 73,693 | 2,210,494 | 5.8 | 3.3 |
| 1931 | 58,034 | 1,831,918 | 3.5 | 3.2 |
| 1932 | 46,199 | 1,523,800 | 3.2 | 3.0 |
| 1933 | 36,973 | 1,420,000 | 3.8 | 2.6 |
| 1934 | 40,558 | 1,535,360 | 3.9 | 2.6 |
| 1935 | 49,732 | 1,651,986 | 4.3 | 3.0 |
| 1936 | 67,503 | 1,765,722 | 4.6 | 3.8 |
| 1937 | 108,474 | | | 6.0* |

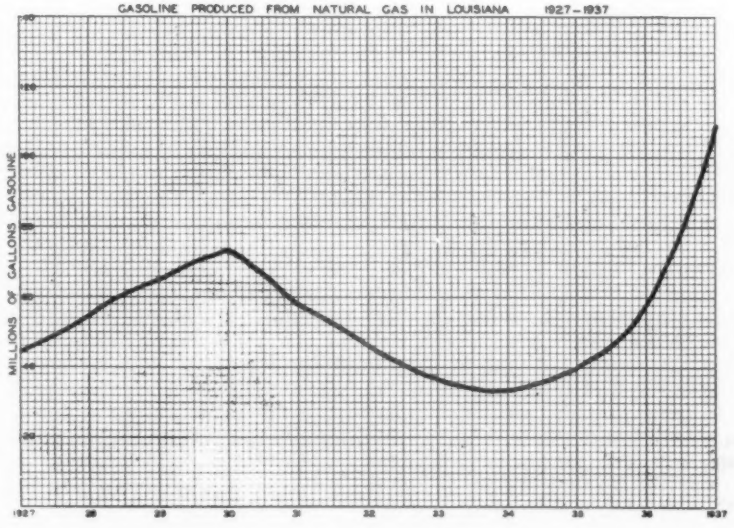
*Source: 1927-1936 Minerals Yearbook, 1937 and 1937 Louisiana Department of Conservation.*
** Estimate for 1937.*

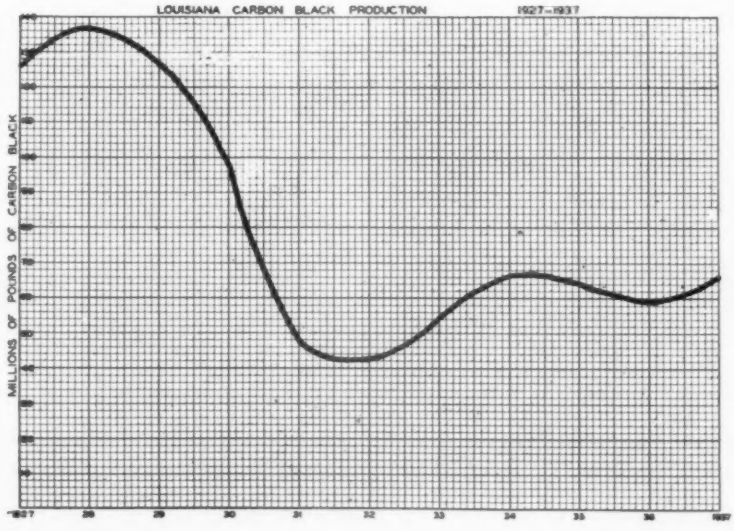
**Carbon Black Produced in Louisiana and United States 1927-1936**

| | Louisiana Carbon Black Production in M Pounds | United States Carbon Black Production in M Pounds | Average Value in Cents Per Pound | Louisiana Production as a per cent of U. S. Production |
|---|---|---|---|---|
| 1927 | 124,188 | 198,429 | 5.52 | 62.5 |
| 1928 | 136,320 | 248,790 | 5.54 | 54.8 |
| 1929 | 127,345 | 366,442 | 5.11 | 37.5 |
| 1930 | 96,729 | 379,942 | 3.91 | 25.4 |
| 1931 | 57,485 | 280,907 | 3.07 | 20.4 |
| 1932 | 42,260 | 242,700 | 2.75 | 17.8 |
| 1933 | 54,470 | 273,125 | 2.78 | 19.9 |
| 1934 | 66,538 | 328,828 | 3.54 | 20.2 |
| 1935 | 64,875 | 352,749 | 3.90 | 18.3 |
| 1936 | 59,201 | 411,345 | 3.92 | 14.3 |
| 1937 | 66,317* | | | |

*Source: Minerals Yearbook, 1937.*
** Louisiana Department of Conservation figures for 1937.*




**Louisiana Metered Natural Gas Production 1917-1937**

(M Cubic Feet at 10 oz. pressure)

| | |
|---|---|
| 1917 | 35,000,000* |
| 1918 | 45,869,346 |
| 1919 | 62,240,585 |
| 1920 | 60,625,156 |
| 1921 | 62,659,857 |
| 1922 | 76,595,852 |
| 1923 | 111,891,169 |
| 1924 | 159,566,050 |
| 1925 | 156,615,000 |
| 1926 | 159,296,000 |
| 1927 | 186,961,000 |
| 1928 | 227,821,000 |
| 1929 | 262,680,782 |
| 1930 | 266,380,184 |
| 1931 | 222,471,691 |
| 1932 | 198,694,147 |
| 1933 | 193,202,645 |
| 1934 | 230,292,473 |
| 1935 | 253,174,592 |
| 1936 | 283,813,709 |
| 1937 | 301,147,717 |
| Totai | 3,532,770,955** |

** Estimate.*
*** Includes all metered gas produced in Louisiana prior to 1937.*
*Source: Department of Conservation.*

of the sulphur development at Lake Washington. However, the recent deeper fields have in some cases shown a tendency to high gas-oil ratios, and it is quite possible that the Coastal area may yet assume a place of importance in commercial gas production.

In the north, deep drilling, in the last few years, has opened up a wealth of gas reserves of which very little is known except their probable tremendous size. The development of gas and, later, oil at Rodessa led to a revival of deep prospecting and carried the wildcatters into the formerly "blind area," the north central basin between the Sabine Uplift and the Monroe Field. The search for oil, besides opening up the Lisbon Oil Field, found oil in deeper sands in the Sugar Creek Field, and gas farther out in the basin in the Simmsboro, Driscoll, and Bear Creek Fields. All of these fields yield a gas extremely rich in recoverable fluids. Because no adequate gas market has been developed for the new fields, only two or three wells have been drilled in each, and no definite opinion can safely be formed on their extent.

In the Sabine Uplift Area tremendous gas reserves in the Trinity group have been opened up in Rodessa, Cotton Valley, Sligo, Blanchard, Dubberly (Sibley), and Lake Bistineau. Strong indications of similar gas production in the deeper sands have been found in the Converse, Zwolle and Shongaloo fields.

These deep gas reserves, all more or less similar in nature, are sufficient in volume to justify major expansion in gas pipe line outlets from the state, and to assure an ample supply for any future industrial expansion within the state.

Considerable time and effort is now being devoted to the search for some outlet for the new fields. Though the fluid content of the yield from the new wells is sufficient to justify hope of satisfactory returns from recycling operations, pressures are uniformly too high for economic operation using absorption methods for stripping. Recent developments in stripping methods depending for their success on temperature and pressure changes, rather than on mineral seal oil absorption, methods that permit of economical operation at very high pressures, give strength to the hope that the near future will find in recycling a solution for the problems in the new deep fields.

*Photo courtesy The Barrett Company*

Southern Natural Gas Co. coated 12 inch pipe line in sand on Louisiana side of Mississippi River crossing.

More remote, probably, than recycling, but still within reasonable hope of attainment, is the possible future market for gas in the manufacture of gasoline. Polymerization of methane and ethane, now purely a laboratory operation because of the extremely high temperatures and pressures required for stabilization, has reached the point where reduction of the necessary pressures and temperatures to within the range of economic operation depends only on the discovery of a suitable catalytic agent.

With reasonably adequate laws and reasonable enforcement, with the realization of its tremendous responsibility as the custodian of one of the nation's greatest fuel reserves, Louisiana looks forward with confidence to the future. Already, during the past year, industrial expansion has shown remarkable development within the state. Louisiana believes in the conservation of natural gas, and defines conservation as intelligent use.

**Louisiana Natural Gas Production by Principal Fie lds in Thousands of Cubic Feet, 1927-37**

| | 1927 and prior years | 1927 | 1928 | 1929 | 1930 | 1931 |
|---|---|---|---|---|---|---|
| Monroe | 728,232,806 | 132,895,666 | 157,561,267 | 170,570,430 | 142,401,460 | 103,178,400 |
| Richland | 1,838,354 | 1,837,404 | 9,916,625 | 42,017,061 | 86,135,483 | 90,485,950 |
| Elm Grove | 146,726,056 | 7,598,818 | 12,071,756 | 13,995,682 | 12,297,167 | 10,018,739 |
| Rodessa | ..... | ..... | ..... | ..... | ..... | 227,670 |
| Caddo-Pine Island | 115,093,818 | 11,956,293 | 4,673,866 | 2,156,587 | 3,549,930 | 2,170,443 |
| Cotton Valley | 12,824,841 | 5,341,222 | 13,461,448 | 18,584,612 | 13,508,953 | 4,103,990 |
| Shongaloo | 46,560,778 | 10,409,651 | 13,238,825 | 5,468,375 | 2,019,884 | 1,202,415 |
| Bull Bayou | 42,289,557 | 2,182,354 | 2,744,896 | 3,258,036 | 2,525,622 | 1,838,035 |
| Sugar Creek | ..... | ..... | ..... | ..... | ..... | 3,801,906 |
| Springhill-Sarepta | 17,276,098 | 4,119,347 | 4,253,038 | 2,641,104 | 455,259 | 347,061 |
| Waskom Bethany | 4,506,754 | 2,047,307 | 3,051,318 | 1,576,143 | 1,208,957 | 1,389,303 |
| Total | 1,123,508,222 | 181,169,793 | 232,820,319 | 262,680,782 | 266,380,184 | 222,471,691 |

| | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1937 and prior years |
|---|---|---|---|---|---|---|---|
| Monroe | 95,853,790 | 113,424,295 | 163,376,378 | 181,698,039 | 205,251,588 | 197,992,348 | 2,259,540,801 |
| Richland | 81,163,374 | 56,449,102 | 32,373,118 | 21,450,393 | 12,218,415 | 8,283,967 | 442,331,843 |
| Elm Grove | 2,308,171 | 2,252,053 | 2,588,649 | 2,137,970 | 1,925,434 | 1,497,448 | 207,819,125 |
| Rodessa | 1,383,120 | 7,784,211 | 13,934,264 | 22,346,119 | 42,411,550 | 56,338,906 | 144,425,840 |
| Caddo-Pine Island | 1,272,959 | 1,198,276 | 1,138,747 | 1,293,991 | 1,527,978 | 1,157,342 | 135,233,937 |
| Cotton Valley | 2,725,598 | 2,149,976 | 1,963,838 | 1,767,971 | 2,057,455 | 10,400,887 | 83,549,569 |
| Shongaloo | 920,942 | 753,132 | 384,531 | 151,029 | 146,678 | 148,974 | 70,995,564 |
| Bull Bayou | 1,670,150 | 3,071,266 | 1,467,928 | 1,266,636 | 1,323,610 | 1,135,423 | 62,591,159 |
| Sligo | ..... | ..... | 3,952,601 | 4,910,034 | 8,756,643 | 13,826,969 | 31,446,247 |
| Sugar Creek | 3,958,095 | 3,695,232 | 4,245,021 | 5,715,861 | 5,466,001 | 4,534,001 | 31,416,117 |
| Springhill-Sarepta | 306,694 | 160,927 | 48,220 | 34,703 | 23,985 | 21,702 | 25,568,791 |
| Waskom Bethany | 1,768,245 | 1,500,679 | 1,049,636 | 841,478 | 453,740 | 272,975 | 15,571,921 |
| Total | 198,694,147 | 193,202,645 | 230,292,473 | 253,174,592 | 283,813,709 | 301,147.717 | 3,532,770,955* |

*Source: Louisiana Department of Conservation*

** This figure includes all metered gas produced in Louisiana prior to 1937; 3,510,490,914,000 cubic feet of gas have been produced from these twelve fields; and 22,280,041,000 cubic feet of gas have been produced from other fields in Louisiana not listed in this table.*

WALTER F. G. STEIN
Chief Chemist

# Natural Gas In Texas

by
**Walter F. G. Stein**

Chief Chemist,
Texas Railroad Commission

A. M. CROWELL
Chief Gas Engineer

THE encroachment of natural gas upon the market previously supplied by manufactured gas, wood, and coal fuel continues and is at the present slowing down the natural expansion of other fuel industries. The question arises often as to what extent the natural gas producers will be able to continue serving the communities connected and for how long.

No estimates destined to answer that question are accurate, for in the continuation of gas field discoveries, new reservoirs will be found which would make today's estimates inaccurate tomorrow. But the assurance that today's known reserves will be able to take care of all its present and future customers for decades to come seems justified when we consider that only a small percentage of the vast amount of gas is being withdrawn annually.

The waste which was imminent in most of the nation's gas fields has been eliminated in this state and modern sensible conservation is practiced.

Up to the present, the gas reserves in the State of Texas have not been definitely calculated. The total potential of all gas wells approximates 42,000,000,000 cubic feet of gas per day, of which 25,000,000,000 cubic feet are located in the Panhandle Area. A rough estimate of the gas reserves, however, indicates that Texas will be able to supply its present, and even an increased market demand for 40 more years; and it is expected, with the discovery of new fields, that the life of Texas' gas industry may extend beyond that period.

There are three kinds of natural gas to be considered in Texas. First, that gas which is produced in the oil fields incident to the production of oil, and commonly known as casinghead gas. This is mainly used in the development of the respective oil fields, supplying drilling rigs and power plants with their fuel requirements. However, large amounts are also distributed through pipe lines for domestic and industrial uses. Laws in Texas permit casinghead gas to be used as a raw material for carbon black production, and large amounts are consumed in such factories.

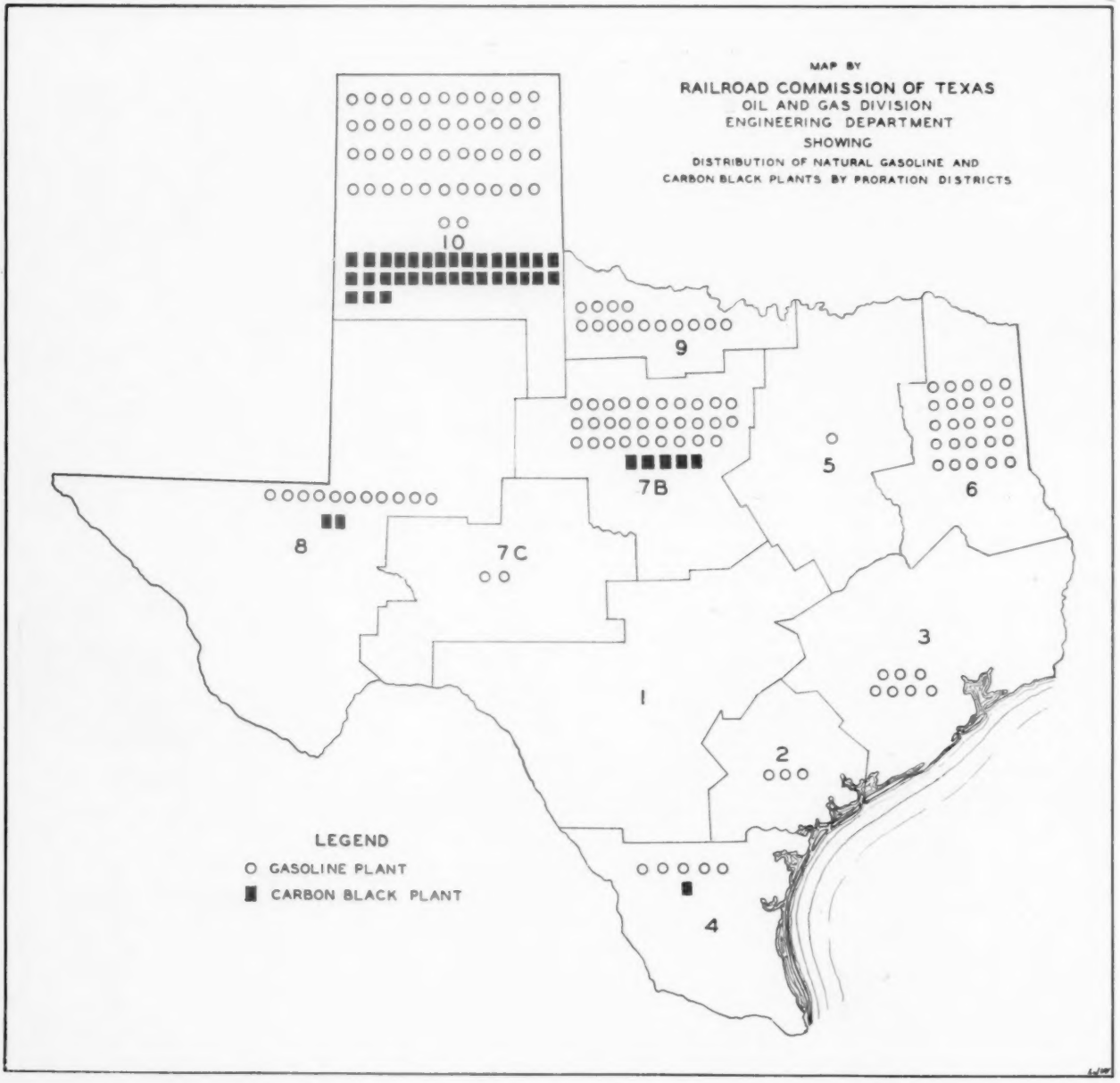
The second kind of gas is that which is called "sour dry" gas. It is produced to a large extent in the Panhandle and West Texas. Its excessive content of sulphur compounds (hydrogen sulfide and mercaptan) makes it an undesirable fuel for domestic and commercial uses. However, it is used in smelters and carbon black plants of the Panhandle, and vast amounts are utilized in this way. This gas commingled with "dry sweet" gas is used to a small extent for marketing and distributing purposes.

The third kind of natural gas is the so-called "dry sweet" and represents the bulk of the gas produced in Texas. This gas, containing little or no hydrogen sulfide, is the most valuable, due to the fact that in its use it does not cause excessive corrosion and does not form obnoxious compounds when properly burned.

Laws intended to prevent waste, and covering most of Texas' production and also most of its reserves, have been passed by the Texas Legislature and are contributing their part to assure a cheap and clean fuel to coming generations.

Occurrence — It is somewhat difficult to describe the occurrences of natural gas in Texas because so many fields were developed before the introduction of detailed histories and records of fields. However, the first important oil fields in Texas produced not only oil, but also gas in commercial quantities. The limited demand for gas outside the immediate neighborhood of such field, and the distances to the markets somewhat delayed the construction of pipelines and the consequential use of natural gas.

Coinciding with the discovery and the development of more and more oil fields went the discovery and development of Texas gas reserves, so that in 1906 approximately 50 gas wells were producing 1,000,000,000 cubic feet of gas. This amount was used for heating and lighting purposes in Texas alone, with no export facilities in existence at that time. The drilling of gas wells was somewhat less important than that of oil wells; and many times on en-




countering gas in some field, drilling was slowed down or even abandoned, for the gas represented a product with no special value.

Around 1920, men with broad vision of the some-day great importance of Texas gas fields began to lay large pipe lines from almost every gas field discovered up to that time. The volume transported, however, was small—approximately only 81,000,000,000 cubic feet of gas in 1923—but the connecting up of newer gas reservoirs and the construction of large pipe lines into other states caused a rapid increase in the yearly figures until by 1936 and 1937 an average of approximately 1,813,000,000,000 cubic feet of gas was handled for light and fuel purposes.

Texas has been roughly divided into 11 districts in which there are proven oil and gas fields. Out of 254 countries, 131 have proved old fields, with varying amounts of gas production, and 89 have proven gas fields of either small or great importance. Contrary to drilling practices in the old days when only oil sands were believed to be worthwhile, today many gas fields are systematically drilled and developed.

Considering the proven and most prolific gas fields in the state we begin with the District No. 10, in which by far the most important gas field is located; namely, the Texas Panhandle.

This field, which was first discovered in 1918 began to produce large quantities of gas in 1926. The installation of large pipe lines and the removal of the carbon black industry from older fields into this area caused an enormous and ever increasing production of gas. Production estimates and records show the following values:

**Table I**

**Texas Panhandle Total Gas Production (Estimated) (Billion C. F.)**

| | |
|---|---|
| 1927—566 | 1933—540 |
| 1928—598 | 1934—866 |
| 1929—700 | 1935—894 |
| 1930—690 | 1936—620 |
| 1931—560 | 1937—626 |
| 1932—470 | |

This field accounts for approximately 65% of Texas' dry gas production and is the most important gas field discovered thus far. Large amounts of the gas from this area are exported to northern states. Of

CONROE COMPRESSOR STATION UNITED GAS PIPE LINE COMPANY CONROE FIELD, TEXAS. PHOTO JIM DAVIS FLYING SERVICE. INSERT, REFUGIO GASOLINE PLANT, UNITED GAS PIPELINE CO.

the 3000 producing gas wells in Texas, 1467 are located in this field, scattered in varying per acre density over the 2480 square miles comprising this territory.*

The area comprising roughly the Railroad Commission's Districts Nos. 2, 3 and 4 produced approximately 80,000,000,000 cubic feet in 1936 and 100,000,000,000 cubic feet of dry gas and 100,000,000,000 cubic feet of casinghead gas in 1937. The gas and gas-oil fields in this area, extending from 80 to 120 miles inland, are widely scattered but follow closely along the coast line.

The depths of some of the Gulf Coast fields have been a great revelation to field technologists and present production problems, which were never encountered in the past history of oil and gas production.

The continuous search for oil has resulted in the discovery of very deep gas wells in the lower Rio Grande Valley. Producing horizons are laid as low as 8600 feet below sea level, and have given Texas some of the highest pressure fields known in history. Recent discovery has shown that gas will come from these deep fields with a virgin pressure of 4,100 pounds or more.

The richness of some of these fields has given a new stimulus to the natural gasoline industry, and an expansion of that industry may be expected in every section of the Gulf Coast Area.

Districts 5 and 6, with their numerous prolific oil fields, have given this state some outstanding gas fields also. The oil deposits in this area are rich with gas, and the combined output of the two districts approximates 21.5 billion cubic feet of dry natural gas and 70,000,000,000 cubic feet of casinghead gas. The old Bethany, Panola, and Waskom group, which for years has supplied Dallas, Beaumont, Houston, and other cities, along the pipelines extending south, is still producing approximately 4,500,000,000 cubic feet per annum.

In these fields gas producing sands have been opened with gas levels located above and below each other. From depths as low as 950 feet (Nacatosh formation) through 1900 feet (Blossom), 2300 feet (Barlow), 2600 (Roquemore), 2800 and 2950 feet (Florsheim), 3200 and 3300 feet (Tiller), drilling has penetrated to 4700 feet (Roquemore Deep). In the neighboring Carthage Field, a deep test to the 5960 foot sand has opened an additional reservoir.

Rodessa, the tri-state field, produces vast quantities of gas, which come from prolific oil and gas sands. Great damage is claimed in this field but the efforts of the Commission are meeting with success in curbing waste. The gas produced on the Texas side of the field is largely utilized for supplying many towns and cities through inter- and intrastate lines.

Two rather recent fields, the Long Lake and the Cayuga Field, will some day be counted among the largest producing areas of that part of the state. These fields, although large in the amount of gas present, have a comparatively small output, but successful operation of recycling units in this area will enable operators to obtain the vast amount of gas condensate present. There are other fields with similar conditions scattered throughout Texas and a combined effort on the part of producer and equipment manufacturer will enable operators to derive revenue from them without waste of gas and reservoir pressure.

Located in Central Texas, included in the Commission's Districts 7B and 7C, are some of the older great oil and gas fields. The gas derived from this area during the past decades can only be estimated roughly because the regrettable waste of gas in oil production and in the hope

PHILLIPS LODI GASOLINE PLANT, RODESSA FIELD.

** See articles:—The Panhandle Field and Conservation of Natural Gas, by C. Emery Troxel, American Gas Journal, July, 1937. The Panhandle Oil and Gas Field, by V. E. Cottingham, Director of Production and A. M. Crowell, Chief Gas Engineer, Texas R. R. Commission, American Gas Journal, November, 1937.*

A CAVALCADE OF TRUCKS UNLOADING 20" PIPE FOR GAS OPERATION CONSTRUCTION, LONE STAR GAS COMPANY, DALLAS.

**Table 2**
**Wells, Production and Value of Natural Gas in Texas—1906-1937**

| *Year* | *Wells Drilled* | *Production MCF* | *Value (1000 $)* | *c/MCF Aver.* |
|---|---|---|---|---|
| 1906 | .. | 1,039 * | 151 * b | 14.5 * |
| 1907 | 11 | 1,288 * | 178 * b | 13.8 * |
| 1908 | 10 | 1,752 * | 237 * b | 13.5 |
| 1909 | 23 | 4,365 * | 453 * b | 10.38 |
| 1910 | 11 | 8,110 * | 957 * b | 11.8 |
| 1911 | 37 | 5,503 | 1014 b | 18.44 |
| 1912 | 11 | 7,470 | 1405 b | 18.81 |
| 1913 | 22 | 12,160 | 2073 b | 17.05 |
| 1914 | 37 | 17,434 | 2470 b | 18.38 |
| 1915 | 28 | 13,324 | 2594 b | 19.47 |
| 1916 | 66 | 15,810 | 3144 b | 19.89 |
| 1914 | 37 | 13.434 | 2470 b | 18.38 |
| 1918 | 100 | 13,440 | 5027 b | 37.40 b |
| 1919 | 63 | 24,710 | 4343 b | 17.6 b |
| 1920 | 277 | 37,063 | 7042 b | 19.0 b |
| 1921 | 212 | 44,504 | 8893 b | 20.0 b |
| 1922 | 113 | 47,945 | 3835 | 8.0 |
| 1923 | 84 | 74,535 | 3809 | 5.1 |
| 1924 | 128 | 107,247 | 4065 | 3.8 |
| 1925 | 181 | 134,872 | 7040 | 5.2 |
| 1926 | 263 | 175,392 | 10085 | 5.7 |
| 1927 | 461 | 254,063 | 16204 | 4.4 |
| 1928 | 558 | 301,990 | 10328 | 3.4 |
| 1929 | 579 | 464,928 | 15575 | 3.3 |
| 1930 | 446 | 517,880 | 18488 | 3.6 |
| 1931 | 248 | 464,580 | 10081 | 2.2 |
| 1932 | 167 | 456,832 | 9868 | 2.2 |
| 1933 | 140 | 475,691 | 11331 | 2.4 |
| 1934 | 277 | 602,976 | 13145 | 2.2 |
| 1935 | 276 | 642,366 | 13233 | 2.1 |
| 1936 | 388 | 734,561 | 16895 | 2.3 |
| 1937 | 425 | 891,750 | 20510 | 2 3 |
| | 5760 | | | |

*b—At point of consumption. * Include Louisiana and Alabama. Sources: Petroleum Facts and Figures; Mineral Resources, and Bureau of Mines.*

*—Compiled by Jack Baumel*

**Table 3**
**Total Dry Gas Production For the State of Texas**

| *District* | *1936 Production* | *1937 Production* | *1937 No. Wells Producing* |
|---|---|---|---|
| 1. South Texas | 1,789,264 | 2,319,766 | 101 |
| 2. Gulf Coast and Middle | 33,493,905 | 34,592,919 | 147 |
| 3. Gulf Coast and Upper | 15,435,160 | 27,480,469 | 148 |
| 4. Gulf Coast and Lower | 32,015,601 | 38,773,488 | 386 |
| 5. Central East Texas | 581,337 | 480,434 | 9 |
| 6. East Texas | 19,701,159 | 21,093,292 | 349 |
| 7. Central West Texas | 19,208,232 | 24,177,512 | 554 |
| 8. West Texas | 4,743,849 | 9,360,219 | 43 |
| 9. North Texas | 1,376,856 | 1 809,931 | 76 |
| 10. Panhandle | 443,688,067 | 500,869,114 | 1,448 |
| TOTAL STATE | 572,032,430 | 660,957,144 | 3,261 |

of making oil fields out of gas fields by blowing wells down was the greatest in this area. Nevertheless, the area comprising District 7B has been and is delivering today large quantities of gas for domestic and industrial consumption. Approximately 90,000,000,000 cubic feet came from this area in 1937, most of the production coming from numerous fields in Eastland, Palo Pinto, Erath, Shackelford, and Stephens Counties.

District 8, comprised of West Texas, has had, quite recently, a large gas production. The presence of sour gas, i. e., gas that contains large amounts of hydrogen sulfide and mercaptans, and the fact that it comprises Texas' most sparcely populated area, have hindered the development of gas production. However, the entrance of the carbon black industry into this area has at least given some of the fields a fair chance to utilize some of the production by converting it into a marketable commodity.

Undoubtedly some of the major future reserves are located in West Texas. Producing only about 4% of its daily open flow capacity, its total production amounted to 9,000,000,000 cubic feet of dry gas in 1937. However, an additional production of approximately 40,000,000,000 cubic feet of casinghead gas puts it among some of the major producing areas in the United States.

The two remaining districts, Districts 9 and 1 respectively, are located in North and South Texas. The North Texas district is a small producer of dry natural gas; however, the development of the K. M. A. oil field will ultimately raise its total gas output considerably. The gasoline cubic feet has stimulated thousand cubic feet has stimulated recent expansion of gasoline extraction facilities in these fields, and has placed them far above the state's average of gallons of gasoline per thousand cubic feet of gas recovered.

Surpassing District 9 (North Texas) when the total output of any natural gas is 1.8 billion cubic feet, District No. 1 has an output of 2.3 billion. On the other hand it has never produced as much casinghead gas. (District 9—5.1 billion cubic feet.) This is mostly due to the fact that gas produced incident to the oil is negligible and in some cases what little there was has been depleted.

A summary of the production of Texas by years is included under Table 2, which shows the total gas produced.

A comparison of the Districts (Table 3) shows the production of dry gas in 1936 and 1937.

### Table 4

**Major Gas Fields in Texas**

| *Name of Field* | *Production, 1937 (Mill. cubic feet)* |
|---|---|
| Texas Panhandle | |
| West Sweet gas | 241,083 |
| West Sour gas | 218,928 |
| East Sweet gas | 40,857 |
| Refugio | 19,639 |
| Pledger | 8,051 |
| Saxet | 7,800 |
| Cole Bruni | 6,810 |
| Winkler County | 6,078 |
| Agua Dulce | 6,044 |
| Eastland County | 5,572 |
| Waskom Bethany | 5,535 |
| Rodessa | 5,135 |
| Long Lake | 4,452 |
| Cayuga | 4,251 |

THE MAJESTIC TOWERS OF RED RIVER BRIDGE, NORTH BYERS—LONE STAR GAS COMPANY.

Outstanding among gas pipeline bridges in the Southwest is Lone Star Gas Company's 2,256-foot suspension bridge over the Red River near Byers, Tex., carrying two 12-inch pipelines which transport gas from the Southern Oklahoma fields to the company's compressor station at Petrolia.

There are two main spans, each 752-feet in length, and two half spans, 376-feet long, suspended at an average height of 30 feet above the river bed. The spans are supported from three main towers and two rest piers, which consist of 60-foot steel towers resting on concrete piers. An expansion loop, 40-feet high, at each tower avoids line breaks from temperature changes.

### Table 5

**Distribution of Gas Produced in Texas**

| | *1936* | | *1937* | |
|---|---|---|---|---|
| | *Volume in Mill. C. F.* | *% of Total* | *Volume in Mill. C. F.* | *% of Total* |
| Oil field uses, Plant and Lease Operation | 98,429 | 11.65 | 130,207 | 13.09 |
| Repressuring and recycling | 6,220 | .74 | 22,775 | 2.29 |
| Vented to air | 100,876 | 11.94 | 91,341 | 9.19 |
| Extraction loss in gasoline production | 40,111 | 4.75 | 47,708 | 4.80 |
| To carbon black manufacturer | 228,605 | 27.06 | 300,248 | 30.20 |
| To pipelines for gas and fuel | 370,500 | 43.86 | 401,823 | 40.43 |
| TOTAL | 844,738 | 100.00 | 994,103 | 100.00 |

### Table 6

**Growth of Natural Gas Consumption in Texas—By type of use**

| | *Domestic and Commercial* | | *Total Approx. Value at Pt. of Consumption* | | |
|---|---|---|---|---|---|
| *Year* | *No. of Consumers (Thous.)* | *Quantity Consumed (Billion Cu. Ft.)* | *Domestic Commercial* | *Industrial Field* | *Total* |
| 1906 | 703 | .30* | 83,230* | 67,375* | 150,695* |
| 1907 | 1,250 | .34* | 105,272* | 73,004* | 178,276* |
| 1908 | 1,225 | .47* | 132,950* | 103,887* | 236,837* |
| 1909 | 2,322 | .77* | 208,774* | 244,479* | 453,253* |
| 1910 | 14,719 | 1.62* | 514,782* | 441,901* | 956,683* |
| 1911 | 22,972 | 1.6 * | 631,986 | 382,959 | 1,014,945* |
| 1912 | 27,226 | 2. | 906,412 | 498,665 | 1,405,077 |
| 1913 | 37,350 | 3. | 1,286,667 | 787,156 | 2,073,823 |
| 1914 | 48,547 | 4. | 1,678,858 | 790,912 | 2,469,770 |
| 1915 | 59,386 | 5. | 1,858,308 | 735,565 | 2,593,873 |
| 1916 | 68,218 | 5. | 2,112,893 | 1,030,978 | 3,143,871 |
| 1917 | 73,706 | 7. | 2,464,099 | 969,024 | 3,433,123 |
| 1918 | 79,865 | 7. | 2,795,265 | 2,723,197 | 5,518,462 |
| 1919 | 86,851 | 9. | 3,522,000 | 3,130,000 | 6,652,000 |
| 1920 | 105,599 | 10. | 4,318,000 | 5,080,000 | 9,398,000 |
| 1921 | 117,843 | 10. | 5,680,000 | 5,040,000 | 10,721,000 |
| 1922 | 157,530 | 11. | 6,946,000 | 7,219,000 | 14,165,000 |
| 1923 | 177,070 | 13. | 8,406,000 | 5,351,000 | 13,757,000 |
| 1924 | 196,560 | 15. | 9,067,000 | 5,847,000 | 14,914,000 |
| 1925 | 212,240 | 15. | 9,887,000 | 12,094,000 | 21,982,000 |
| 1926 | 279,380 | 18. | 11,986,000 | 11,821,000 | 23,807,000 |
| 1927 | 328,510 | 21. | 14,019,000 | 25,122,000 | 40,141,000 |
| 1928 | 420,060 | 28. | 18,305,000 | 35,965,000 | 54,270,000 |
| 1929 | 503,070 | 39. | 24,878,000 | 40,699,000 | 65,577,000 |
| 1930 | 521,550 | 41. | 27,145,000 | 43,542,000 | 70,687,000 |
| 1931 | 531,930 | 43. | 27,906,000 | 31,420,000 | 59,326,000 |
| 1932 | 527,020 | 40. | 26,430,000 | 23,896,000 | 50,326,000 |
| 1933 | 529,300 | 34. | 23,497,000 | 22,556,000 | 46,053,000 |
| 1934 | 545,560 | 36. | 24,633,000 | 23,678,000 | 48,311,000 |
| 1935 | 568,310 | 39. | 23,634,000 | 26,139,000 | 49,773,000 |
| 1936 | 598,000 | 44. | 28,592,000 | 25,378,000 | 53,970,000 |

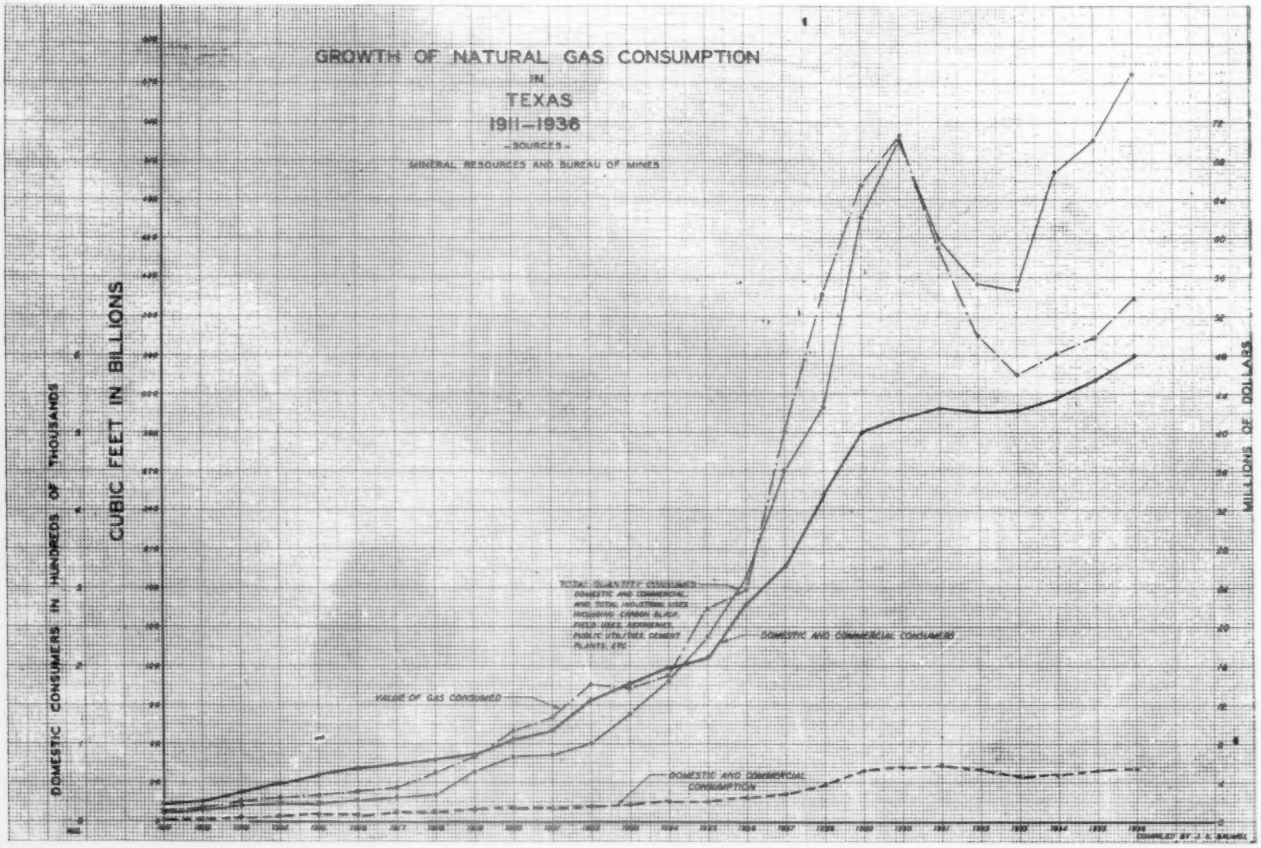
* *Alabama and Texas.*

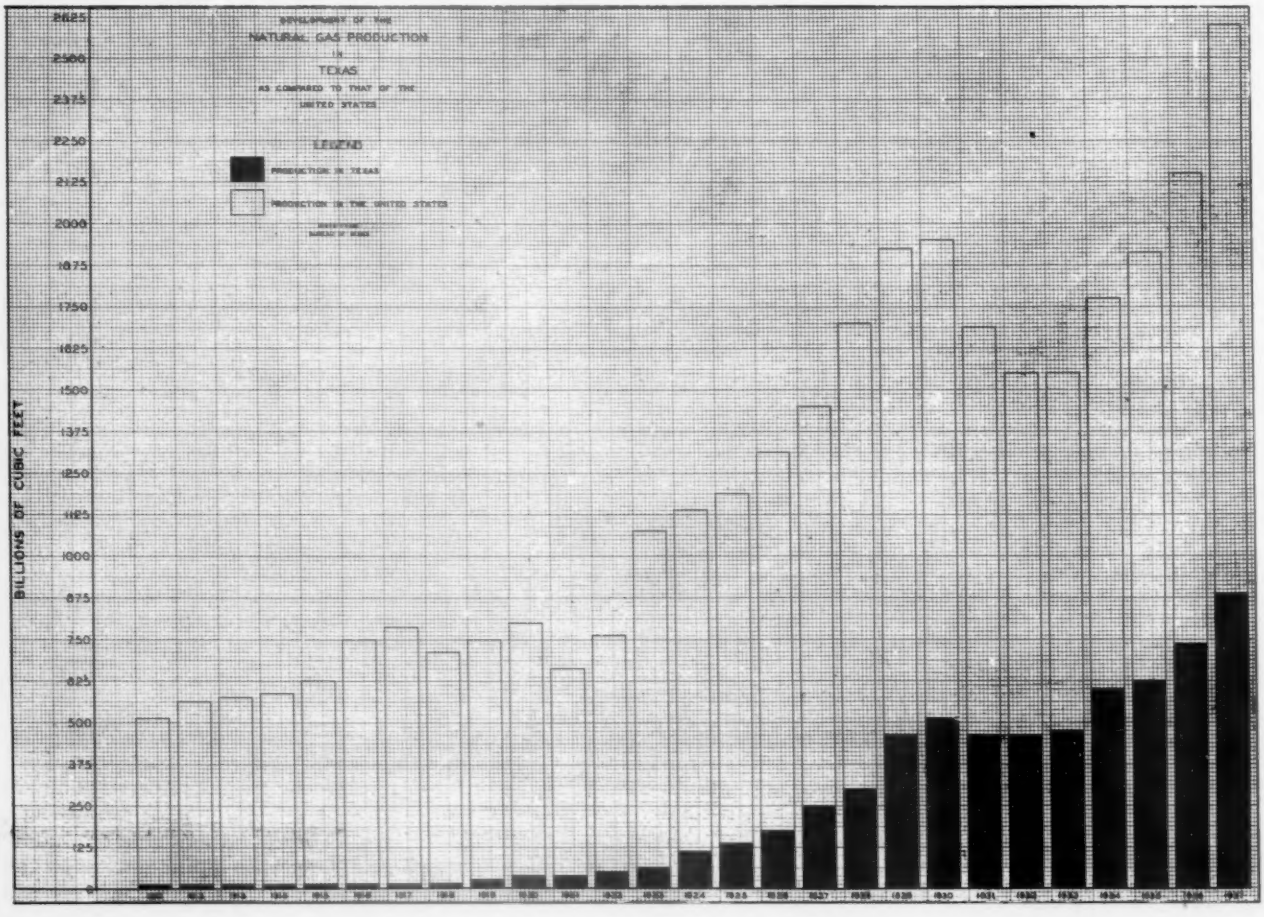
*Source: American Petroleum Institute; Mineral Yearbook; Arnold and Kemnitzer's "Petroleum In The United States and Possessions."*

The major dry gas fields in Texas are listed in sequence of their importance in Table 4.

The network of pipe lines knitted closely over Texas is continually being expanded. Gas systems have for many years supplied all major cities in Texas, and it can be said that Texas has solved its commercial and industrial fuel problems in the development of the gas industry. Industries depending entirely upon the existence of cheap fuel for manufacturing purposes have been drawn to Texas, such as smelters, cement factories, and electric power plants. The oil industry, itself, uses vast quantities of the produced gas.

The demand for oil field power and fuel as well as the amount used for repressuring and recycling have increased during the past year. The increase in oil field consumption, accompanied by the enforcement of laws preventing waste, have resulted in a decrease in the amount of casinghead gas wasted to the air. An


GROWTH OF NATURAL GAS CONSUMPTION
IN
TEXAS
1911—1936
-SOURCES-
MINERAL RESOURCES AND BUREAU OF MINES
DOMESTIC CONSUMERS IN HUNDREDS OF THOUSANDS
CUBIC FEET IN BILLIONS
MILLIONS OF DOLLARS
VALUE OF GAS CONSUMED
DOMESTIC AND COMMERCIAL CONSUMERS
DOMESTIC AND COMMERCIAL CONSUMPTION


DEVELOPMENT OF THE
NATURAL GAS PRODUCTION
IN
TEXAS
AS COMPARED TO THAT OF THE
UNITED STATES
LEGEND
PRODUCTION IN TEXAS
PRODUCTION IN THE UNITED STATES
BILLIONS OF CUBIC FEET

increased gasoline production, and utilization of butanes and propanes at these plants have caused a material increase in the volume lost by extraction.

Carbon black production in the oil fields has increased tremendously and a volume of approximately 32% more gas was used for this industry. The increase in gas volume delivered to pipelines in the field enjoyed an increase of 8.4% in 1937 and 1938.

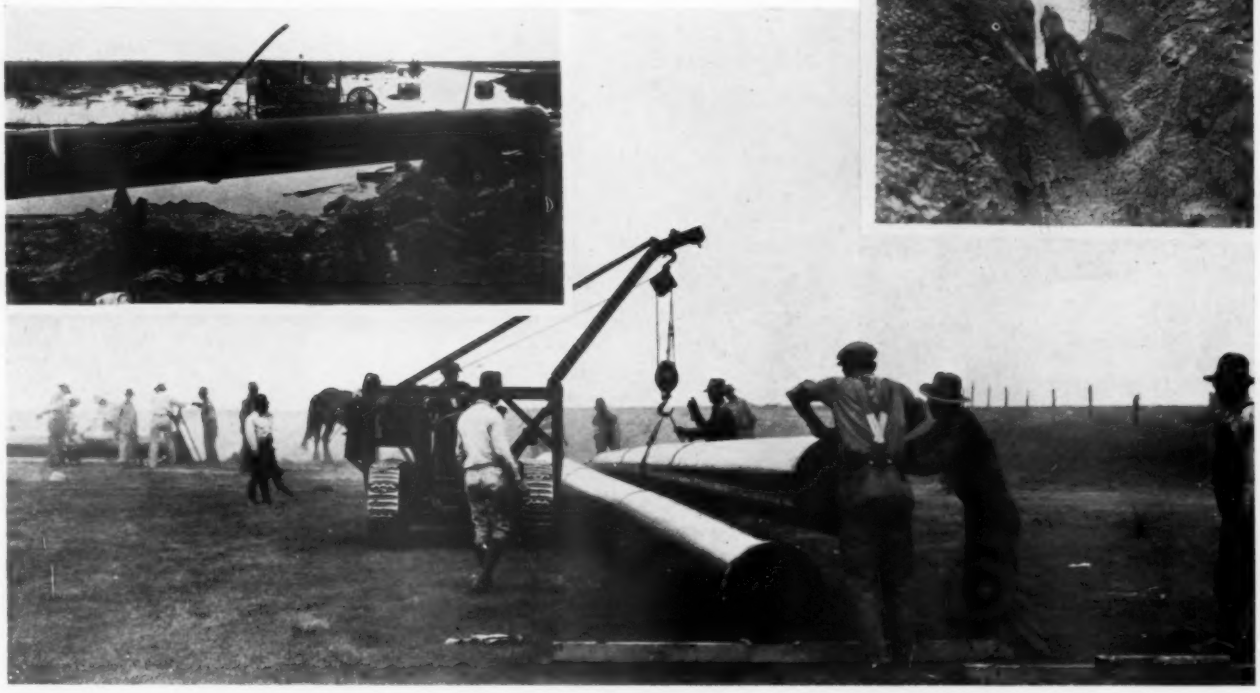
This distribution of gas at point of origin for the two years of 1936 and 1937 is listed in Table 5.

*Natural Gasoline Production*—At the present there are 144 gasoline plants producing in Texas, with an aggregate capacity of 4,246,830,000 cubic feet daily, processing approximately 2,254,999,000 cubic feet, and producing 2,200,000 gallons of gasoline and 300,000 gallons of Butane and Propane daily.

From the accompanying skeleton map, it is easily seen where Texas' gasoline plants are concentrated.

The Panhandle, with a recovery average of approximately .75 gallons of gasoline per thousand cubic feet, leads in the production of this commodity by manufacturing 50%. This is followed by East Texas, which produces an average of 2.46 gallons of gasoline per thousand cubic feet and contributes 25% of the state's

RIGHT:—LAYING PIPE LINE AT CREEK CROSSING —LONE STAR GAS COMPANY. INSERT BELOW;— CONSTRUCTION OF 18" LINE TO SERVE GULF OIL CORPORATION, PORT ARTHUR, TEXAS.



TWENTY-TWO INCH LINE MISSOURI-KANSAS GAS COMPANY UNDER CONSTRUCTION AT STINNETT, TEXAS—LONE STAR GAS COMPANY.

TEXHOMA FRITCH COMPRESSOR STATION.

total output. These two districts in February, 1938, accounted for 1,645,401 gallons of the state's total production of 2,247,129 gallons.

The amount of gas processed in gasoline plants in 1937 amounted to 776,099,000,000 cubic feet, with a production of 730,683,705 gallons of gasoline and 35,000,000 gallons of liquid butane and propane.

*Carbon Black Manufacture*—Texas has been for years the nation's largest carbon black producer. However, in 1937, its production alone set an all time high record for this community.

40 plants with an aggregate total of 1,005,000,000 cubic feet daily capacity convert 838,000,000 cubic feet of sour and casinghead gas into 1,300,000 pounds of carbon black daily. In 1937, the total production of carbon black in Texas amounted to 445,000,000 pounds.

Since these plants depend on large volumes of sour and casinghead gas, the plants are concentrated in those regions where they are in abundance; namely, the Texas Panhandle, West Texas, and the Eastland-Ranger area.

Prior to the development of our gas fields, very few industries were present in Texas, due to scarcity of mined coal and other conventional fuel in Texas. The cheap and abundant supply of gas, however, caused industries to be established in this state which depend on large volumes of cheap fuel.

The production of gas in Texas was also dependent upon the increased demand of other states. Gas pipelines have brought Texas' gas into many other states including Illinois, Kansas, Colorado, Iowa, Indiana, Missouri, Oklahoma, Nebraska, the Republic of Mexico, Minnesota, Louisiana, Michigan, Ohio, New Mexico, South Dakota, and Wyoming, named in sequence of their importance as Texas' customers.

Gas consumers in the nation have reached ten times their original number in the past 30 years and in Texas, alone, the increase has been from 703 domestic and commercial users to 598,000 in 1936. The necessary gas is distributed by more than 100 systems, interurban, rural, and urban.

The history of volumes distributed and their value since 1906 is shown in the following table, Table 6.

The considerable increase in industrial consumption of 632,000,000,000 cubic feet, compared to 533,000,000,000 used in 1936 is to the largest extent due to the increase of consumption of gas by carbon black plants.

**Table 7**

**Growth of Natural Gas Consumption in Texas—By types of use**

INDUSTRIAL CONSUMPTION—Billions of cubic feet

| Year | Field | Carbon Black | Petroleum Refineries | Pub. Ut. Elec. Power | Portland Cement | Other Indus. | Total |
|---|---|---|---|---|---|---|---|
| 1906 | | | | | | | .80 |
| 1907 | | | | | | | .94 |
| 1908 | | | | | | | 1.280 |
| 1909 | | | | | | | 3.594 |
| 1910 | | | | | | | 6.494 |
| 1911 | | | | | | | 3.912 |
| 1912 | | | | | | | 5.12 |
| 1913 | | | | | | | 8.80 |
| 1914 | | | | | | | 9.13 |
| 1915 | | | | | | | 8.40 |
| 1916 | | | | | | | 10.39 |
| 1917 | | | | | | | 10.71 |
| 1918 | | | | | | | 13.07 |
| 1919 | 18 | | | | | 7 | 29.00 |
| 1920 | 30 | | | | | 4 | 40.0 |
| 1921 | 33 | | | | | 7 | 41.0 |
| 1922 | 36 | | | | | 13b | 49 |
| 1923 | 51 | | | | | 18b | 70 |
| 1924 | 61 | | | | | 32b | 93 |
| 1925 | 62 | | | | | 65b | 127 |
| 1926 | 69 | | | | | 100b | 169 |
| 1927 | 103 | 35 | 32 | 24 | b | 54 | 249 |
| 1928 | 106 | 63 | 30 | 30 | b | 63 | 291 |
| 1929 | 128 | 151 | 26 | 38 | 13 | 70 | 427 |
| 1930 | 164 | 176 | 26 | 44 | 11 | 64 | 485 |
| 1931 | 149 | 136 | 25 | 37 | 8 | 49 | 405 |
| 1932 | 145 | 122 | 26 | 31 | b | 51 | 375 |
| 1933 | 138 | 138 | 26 | 28 | 4 | 45 | 378 |
| 1934 | 189 | 168 | 28 | 31 | 4 | 43 | 465 |
| 1935 | 200 | 180 | 26 | 31 | 5 | 44 | 487 |
| 1936 | 204 | 228 | 28 | 36 | b | 57 | 533 |
| 1937* | 208 | 300 | 26 | 38 | b | 60 | 632 |

*b—Included with other industrial consumption.*
** Preliminary estimate.*
*Source: American Petroleum Institute; Mineral Yearbook; Arnold and Kemnitzer's "Petroleum In The United States and Possessions."*

*—Compiled by Jack Baumel*

## Michigan Producers Plan 300-Mile Line

DETROIT, Mich.—The Producers, Natural Gas Pipe Line Co., now being organized by five independent Michigan gas operators claiming to represent 40 per cent of the state's natural gas production, have filed a petition with the Michigan Public Utilities Commission for authority to construct a 300-mile, 10-inch loop gas line from the Six Lakes field to Jackson, Kalamazoo, Flint, Pontiac, Battle Creek, and other similar cities now without natural gas.

Incorporators of the new firm include several independent gas producers who plan to promote greater marketing of gas out of the Six Lakes field. The men are: R. A. Whitehead, Lansing; Roy T. Ide, Guy M. Obenhauer and Edward J. Lieber, all of Detroit; and Paul B. Whitney, Grand Rapids.

### Large Reserves Claimed

The Independents claim developed gas reserves in the state of 400 billion cubic feet as the basis of their right to build a line. They claim to have an open flow at present of 2,000,000,000 cu. ft. a day. Two companies, the Consumers Power Co. and the American Light and Traction Co., now have 8-inch lines running from the Six Lakes field, serving the Saginaw-Bay City Valley area, Lansing district, and Grand Rapids, with a take of approximately 24 million feet daily from Six Lakes.

According to present plans the gas would be piped from the Mecosta, Isabella, Montcalm, Gratiot, Shiawassee, Livingston, Wayne, Allegan and Clinton fields and the line would be laid from Montcalm and Mecosta counties, southeast to the cities of Owosso, Flint and Pontiac, from Montcalm and Mecosta south to Greenville, Belding and Battle Creek, from Battle Creek west to Kalamazoo and east to Jackson and Ann Arbor.

# Rio Vista Gas Field

By

**Claude C. Brown**

Consulting Chief Engineer
Railroad Commission of California

CLAUDE C. BROWN

THROUGH a period of many years, California has produced large quantities of petroleum and natural gas. This prolific production has come mainly from three separate areas, the San Joaquin Valley, the Coastal area, and the Los Angeles Basin. These areas, together, cover that portion of the state from Coalinga Field in Fresno County, on the north, to Huntington Beach Field in Orange County, on the south.

While new fields and extensions of existing fields are being developed in all three of these areas, probably the greatest activity is taking place in the San Joaquin and Sacramento Valleys.

The San Joaquin Valley, toegther with the Sacramento Valley, which lies north of it, form what is known as the Great Central Valley of California. This valley includes an area of approximately 16,000 square miles, extending from Redding in Shasta County, on the north, to the base of the Tehachapi Mountains in Kern County, on the south. It is flanked, on the east, by the Sierra Nevada Mountains, a great single range extending from Lassen Peak southward to Tejon Pass in the northern portion of Los Angeles County and, on the west, by the Coast Ranges.

The upper portion, or the Sacramento Valley, varies in width from ten miles at Redding to forty-five miles at Suisun Bay, into which the Sacramento River discharges. The lower portion, or the San Joaquin Valley, varies from thirty miles in width at Stockton to sixty miles at Hanford, in Kings County. Elevations in the valley range from several hundred to a thousand feet.

**The new Rio Vista gas field is located in this valley. Other oil and gas fields in the Great Central Valley include Belridge, Buena Vista Hills, Buena Vista Lake, Buttonwillow, Coalinga, Edison, Elk Hills, Fellows, Greeley, Kettleman, Lost Hills, Maricopa, McKittrick, McDonald Island, Mountain View, Semi Tropic, Ten Section, Tracy and Trico.**

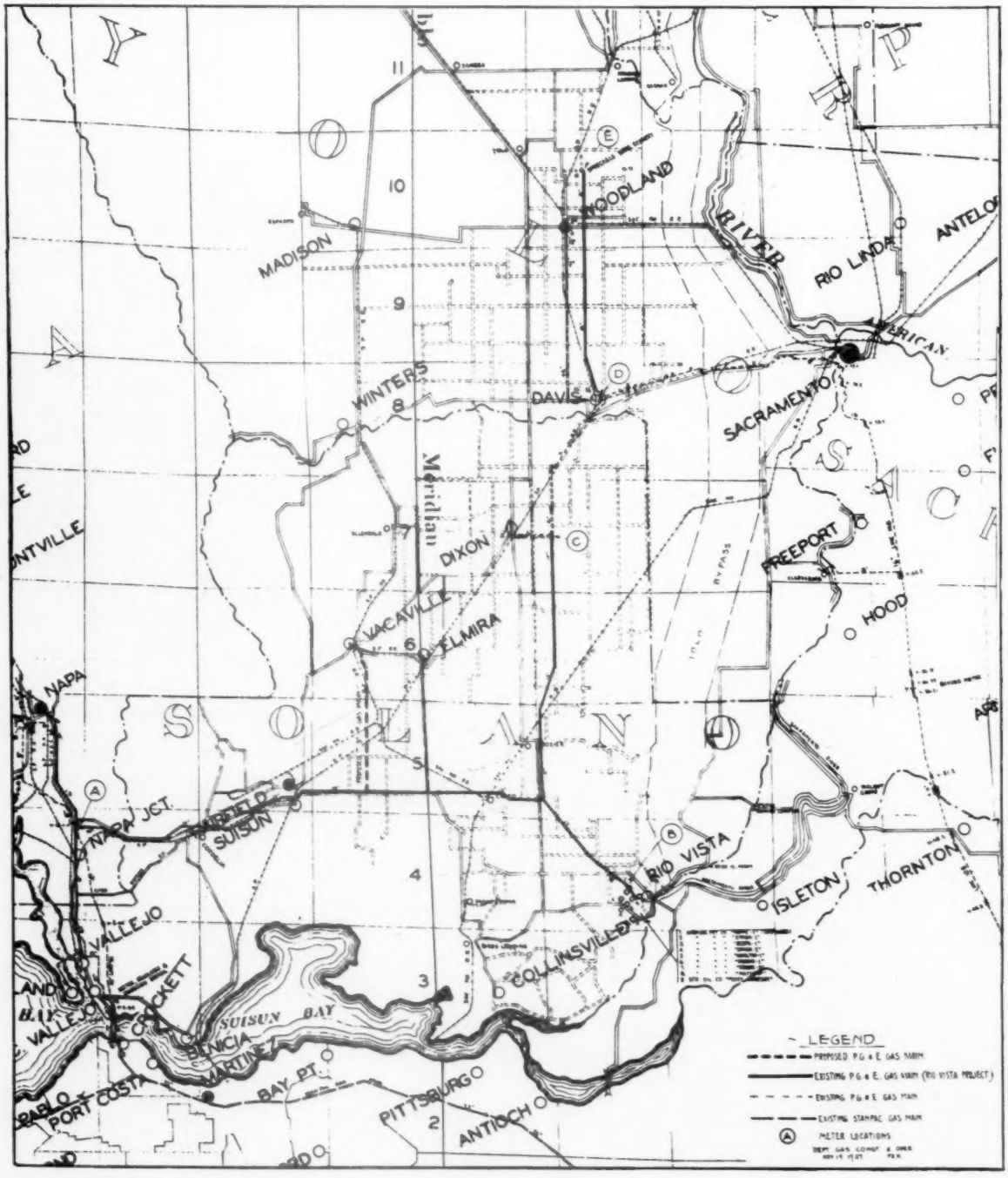
***"The locations of the new Rio Vista and McDonald Island Gas Fields are very advantageous in furnishing additional and substantial sources of gas supply in the immediate neighborhood of its largest market. They provide a valuable source of immediate supply in cases of extreme demand or emergency shutdown of either of the present transmission lines from the south."***

## Geology

The generally accepted theory of the origin of petroleum and natural gas in California is that they resulted from the slow decomposition of animal and vegetable matter at low temperature, with insufficient oxygen for complete decomposition. These organisms, known as diatoms and foraminifera, lived on the surface of warm inland seas formerly existing in the present Great Central Valley, and the other oil producing areas of the state. Their remains sank to the bottom, forming ooze or organic mud in which putrefaction of their organic parts took place, the whole being covered with layers of sedimentary deposits. Earth movements uplifted the mass above the surface of the sea. The resulting heat and pressure of these movements, together with the action of saline waters, distilled the shales, thereby forming liquid and gaseous hydrocarbons.

These organic shales, consisting of marine deposits of fine silt, mingled with the remains of diatoms, foraminifera and other forms of sea life are generally fine-grained, compact in texture, light in weight, and range in color from chocolate-brown, purple and maroon to light gray and white. They vary in hardness from the soft, earthy, "chalky" varieties to hard, flinty and porcelaneous textures.

Geological formations in California, particularly in the petroleum and gas producing areas above mentioned, contain large deposits of these organic shales. All known deposits of petroleum and natural gas in the state are found in close association with these organic shales, either in them or directly above them. They comprise the source medium in which the hydrocarbons are formed and from which they migrate to overlying sands or reservoirs. When these overlying reservoirs are sealed with hard cap rock or other impervious cover, and the latter is folded in anticlinal or dome form or, when a fault seals off the structure or thick impervious beds lie on the top of the uptilted edge of a monocline in unconformity, thus sealing the structure, petroleum or gas catchment basins occur and pools are

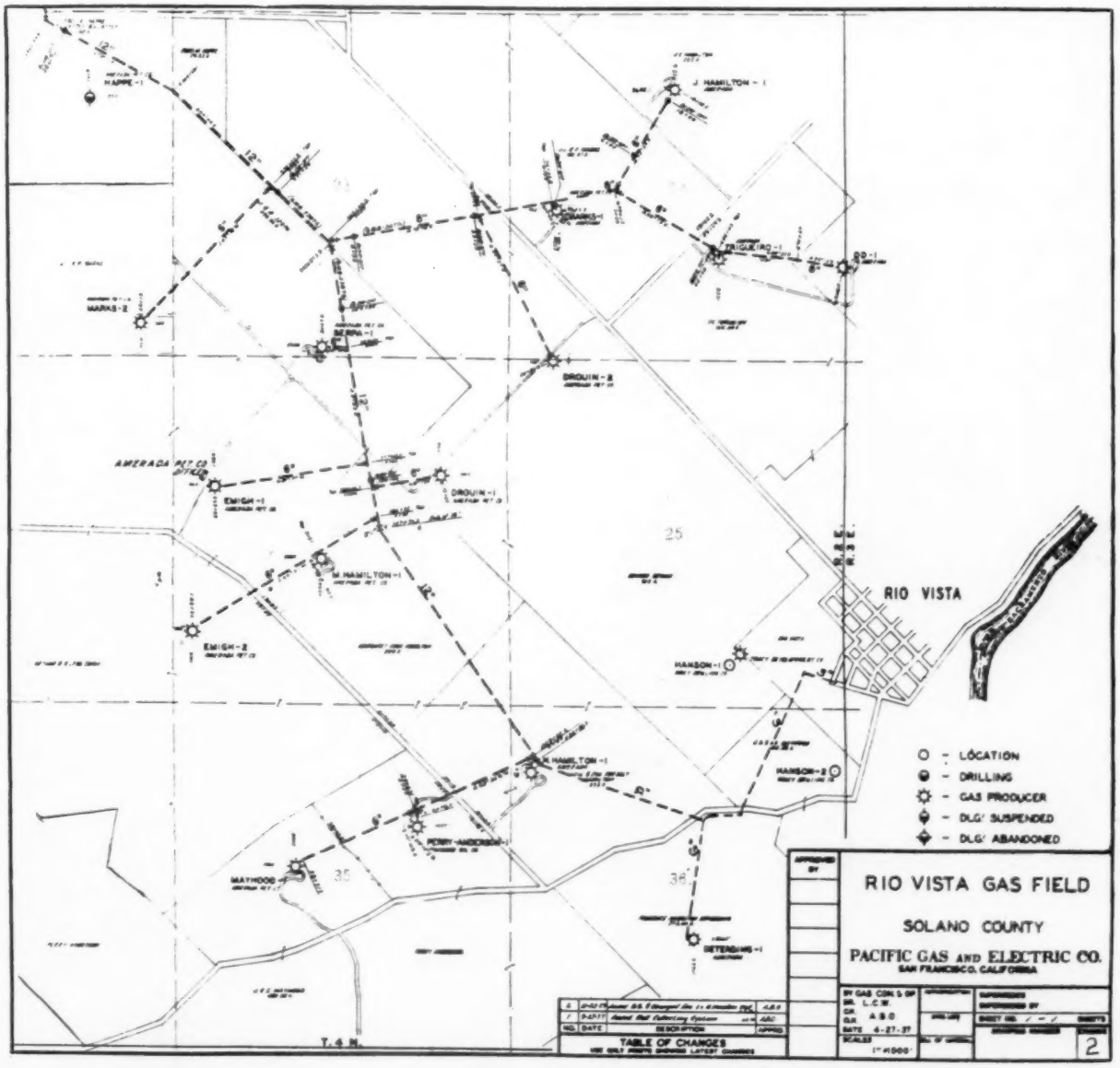



FORTY-SIX MILES NORTHEAST OF SAN FRANCISCO LIES THE RIO VISTA GAS FIELD RECENTLY BROUGHT IN WITH THE COMMUNICATING GAS DISTRIBUTION LINES OF THE CENTRAL PART OF THE STATE.

formed. These organic shales, containing organic material in appreciable quantities are often interspersed with streaks of sand and range in age from Cretaceous to Pliocene.

The surface of the Great Central Valley is covered by alluvium which overlies formations of Cretaceous and Tertiary age. The single interruption of its surface continuity being the Marysville Buttes, in Sutter County, a volcanic mass or plug protruding from the center of the Sacramento Valley. Recent drilling operations in immediate vicinity of these buttes have disclosed the presence of natural gas. Between Red Bluff and Suisun Bay the alluvium of the Valley floor rests, on its western edge, against rocks of Cretaceous age exposed in the foothills of the Coast Range.

The Cretaceous formation apparently underlies the Great Central Valley from Redding, in Shasta County, to a point just south of Coalinga, in Kern County. In this area it attains a remarkable thickness, in some locations as much as 30,000 feet. It consists of two distinct parts. The upper or Chico, with maximum thickness of approximately 8,000 feet, is composed of medium coarse blue-gray and greenish sandstone interspersed with thin beds of dark gray shale. The lower portion, called the Knoxville, is composed of dark, fine-grained, thinly bedded carbonaceous shales interspersed with lenses of fine-grained sandstone. Its




EMBRACING A ZONE WITHIN A SEMICIRCULAR RADIUS OF THREE MILES, THIS FERTILE FIELD HAS EIGHTEEN PRODUCING GAS WELLS.

maximum thickness is approximately 22,000 feet, which occurs along the west side of the Sacramento Valley. The contact between the Chico and the Knoxville is marked generally by a thick bed of conglomerate made up of crystalline pebbles.

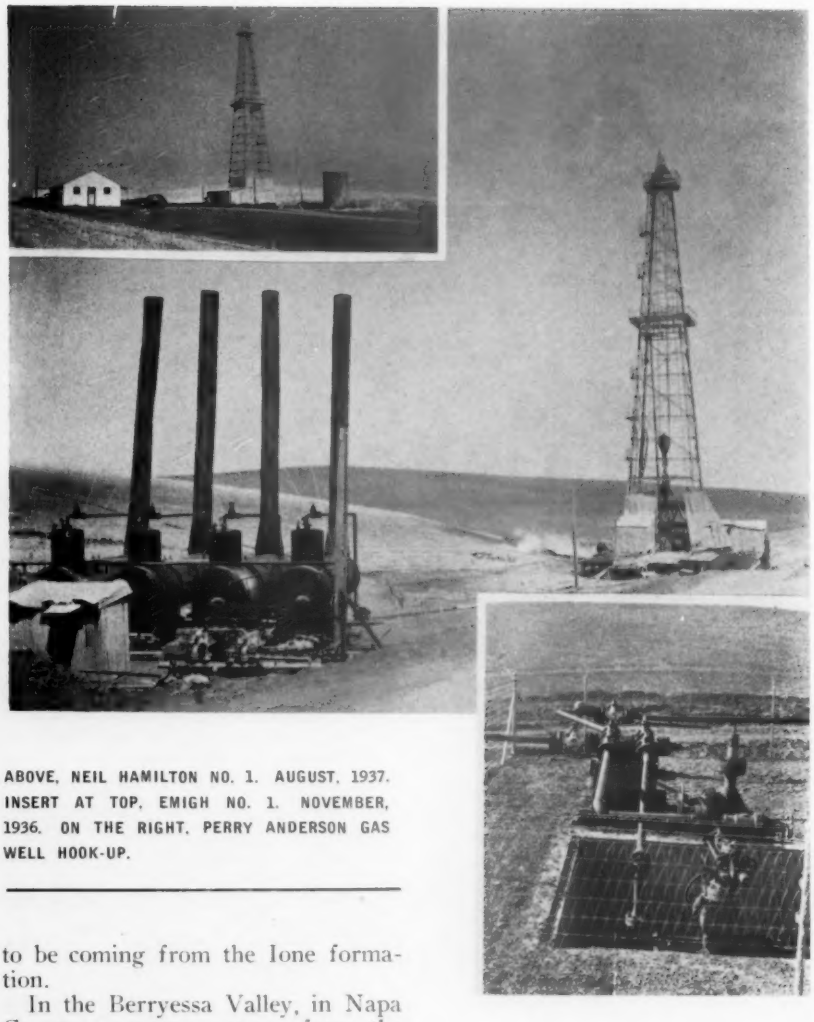
The main body of Cretaceous formation in the Valley occupies the foothill belt along its western edge, an area some fifteen miles wide extending from southern Shasta County to Suisun Bay across the Counties of Tehama, Glenn, Colusa, Yolo, Napa and Solano. The general structure of the Cretaceous is that of a great monocline dipping at an angle of about thirty-five degrees to the east. The foothills have been carved out along the upturned edges of the Cretaceous formation. The medium hard Chico sandstone which marks their eastern edge forms small canyons and ridges with an east and west trend. The underlying softer Knoxville shales mark their western limits and form broad valleys or basins with a north and south trend.

Overlying the Cretaceous, in part, occur beds of conglomerate and yellow sand, probably of Eocene age and resembling the Ione or Tejon deposits of the east side of the Sacramento Valley.

The oldest rocks exposed in the Valley are beds of altered sandstone, chert, schists, and masses of intrusive serpentine of the Franciscan formation (Jurassic). This formation underlies the Cretaceous.

Up to the present time, the northern limit of petroleum production in the Great Central Valley has been the Coalinga Field, although a number of dry gas fields have been developed farther north. These include Tracy, McDonald Island, Rio Vista and The Buttes development.

Numerous seepages of oil and gas have been noted in the northern part of the Great Valley. In Glenn County, in the hills west of Orland, gas seepages come from the Chico sandstone. In Colusa County seepages of light amber oil come from the Knoxville shales along the west side of Bear Valley. In the same county, natural gas blows occur along a faultline running northwest and southeast in Sec. 31, T. 15 N., R. 4 W. In Yolo County seepages of oil and gas occur along the axis of a fault in the Rumsey Hills, which mark the west side of Capay Valley. These appear



ABOVE, NEIL HAMILTON NO. 1. AUGUST, 1937. INSERT AT TOP, EMIGH NO. 1. NOVEMBER, 1936. ON THE RIGHT, PERRY ANDERSON GAS WELL HOOK-UP.

to be coming from the Ione formation.

In the Berryessa Valley, in Napa County, seepages appear from the Knoxville shales in the S.W.¼ of Sec. 25, T. 4 N., R. 3 W. and S.E.¼ of Sec. 34, T. 11 N., R. 4 W. In the Potrero Hills, east of Fairfield, numerous seepages come from the Meganos shales. Gas blows occur in Sections 11 and 14, T. 5 N., R. 1 W., in Solano County, coming from the Chico formation.

Numerous theories have been advanced relating to the geology of the northern portion of the Great Central Valley. One authority contends that the area north of San Francisco Bay comprises a huge dissected plateau consisting of an ancient peneplain which has been uplifted from a nearly base level condition to its present altitude. The extreme thickness and general coverage of the Cretaceous deposits in this area would appear to strengthen this theory. Carrying the thought further, subsequent earth movements and cracks or faults in the basement rock have probably tilted and cracked the massive Cretaceous formation, it being too thick and unwieldy to readily conform to folding or bending, thus allowing the escape of portions of its liquid and gaseous hydrocarbons to overlying formations or to the atmosphere.

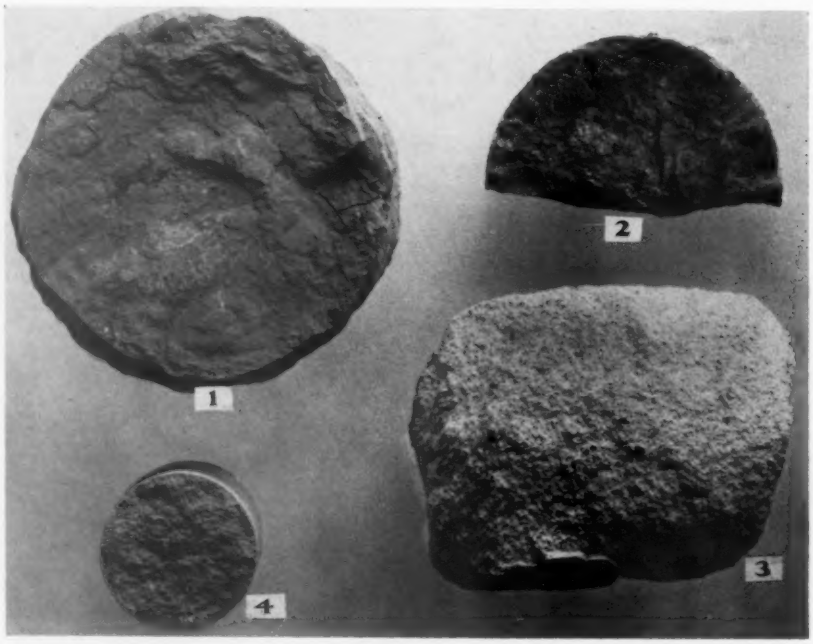
The thinner and more flexible overlying strata were probably folded over these fractures and, where porous and sealed, became catchment reservoirs into which the lighter hydrocarbons from the organic shales of the Cretaceous gradually percolated. Many of these would be small pockets, but some would contain substantial quantities of lighter hydrocarbons, such as those found at McDonald Island and Rio Vista.

### Development

For many years, geologists and others have suspected the existence of natural gas, and possibly petroleum deposits, in that portion of central and northern California lying in the valleys traversed by the Sacramento and San Joaquin Rivers. This theory has been supported by the fact that seepages of both gas and oil have occurred at many locations in the lands adjacent to those rivers, and elsewhere in the Great Central Valley.

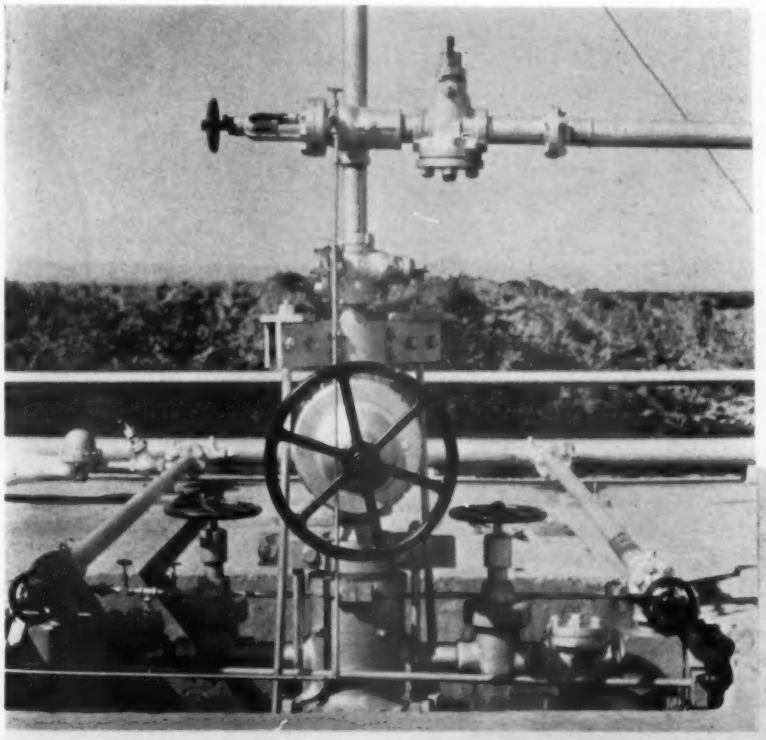
Since the early nineties, natural gas has been collected from water wells near Sacramento and Stockton and used for fuel purposes. Natural gas seepages have also been noted in the vicinity of Suisun and Fairfield and in other locations in this general area.

## CORE SAMPLES




1:—BLUE GRAY SHALE OVERLAYING PRODUCING SAND. 4320' EMIGH NO. 1 HARD AND COMPACT. 2:—STREAK OF LIGNITE IN SHALE. 4345' EMIGH NO. 1. 3:—FINE, WHITE, POROUS PRODUCING SAND. 4360' EMIGH NO. 1. 4:—MEDIUM HARD GRAY SANDSTONE. 6970' HAPPE NO. 1. CHICO FORMATION (CRETACEOUS.)

In the year 1901, the Rochester Oil Co. drilled a well to a depth of 1820 ft. in the N.E.¼ of Sec. 24, T. 5 N., R. 1 W. in Solano County. Natural gas was encountered at 1520 feet and the well produced gas at the rate of 20,000 cubic feet per day for several years. In 1921, the Honolulu Consolidated Oil Co. drilled a well in this same area and also one in Potrero Hills about four miles east of Fairfield, neither of which was a producer.



ABOVE, TRACY FDL NO. 2 WELL.

The terrain is generally flat with little surface indication of the existence of potential underground structures which might act as catchment basins for oil or gas.

With the advent and recent development of geophysical prospecting methods, a number of such hidden structures have been located and successfully drilled.

During the last few years there have been a number of new structures and fields discovered and developed which may be classed as strictly gas fields. This for the reason that while they contain substantial quantities of natural gas, they have thus far produced little or no petroleum.

Among these gas fields may be included the Semi Tropic Field, in Kern County, Tracy, McDonald Island and Roberts Island fields in San Joaquin County, Trico Field, in Tulare County, Rio Vista Field in Solano County, and the Buttes Field, in Sutter County. In addition to these, the recent blowout of a gas well on the Willard Ranch, near Willows, in Glenn County, indicates the existence of natural gas under high pressure in that vicinity.

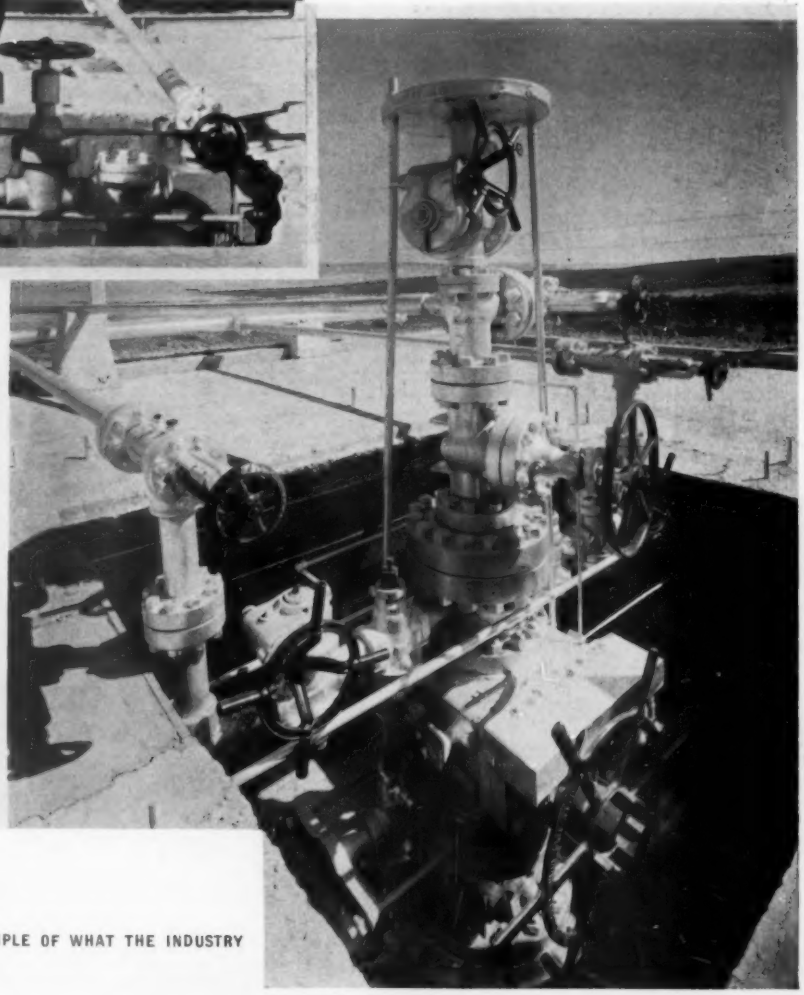
Thousands of acres of land in Merced, Stanislaus, San Joaquin, Solano, Sacramento, Glenn, Colusa, Yolo and Tehama Counties have been leased for gas development.

### Location of Rio Vista Field

**The Rio Vista gas field is located in Townships 3 and 4 North, Range 2 East, M.D.B. & M., at the eastern end of the low-lying Montezuma Hills, in Solano County. It is immediately adjacent to and probably includes the Town of Rio Vista on the Sacramento River, a distance of forty-six miles northeast of San Francisco.**

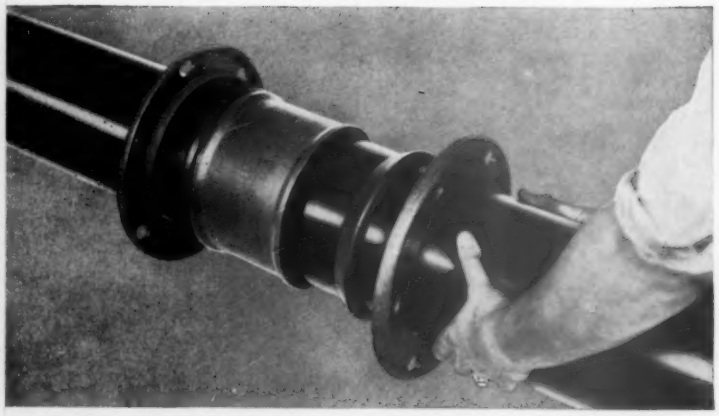
### Discovery Well

The field was discovered through the commendable efforts of the Amerada Petroleum Corporation by the completion of its Emigh No. 1



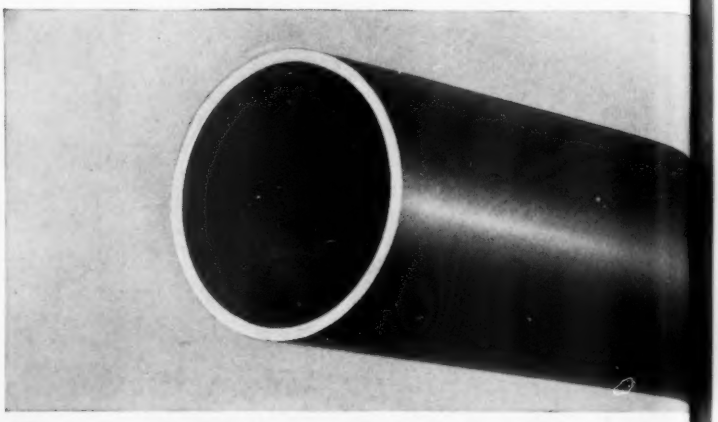
RIGHT, WELL IN RIO VISTA FIELD. A FINE EXAMPLE OF WHAT THE INDUSTRY TERMS A "CHRISTMAS TREE."

# SIMPLIFY*



## 1 . . . STANDARD DRESSER PARTS ARE . . .

● The Dresser joint, like a pre-fabricated house, is made up of simple, standard, "factory-built," interchangeable parts. *No field fabrication is required.* All parts precision-made within close limits.

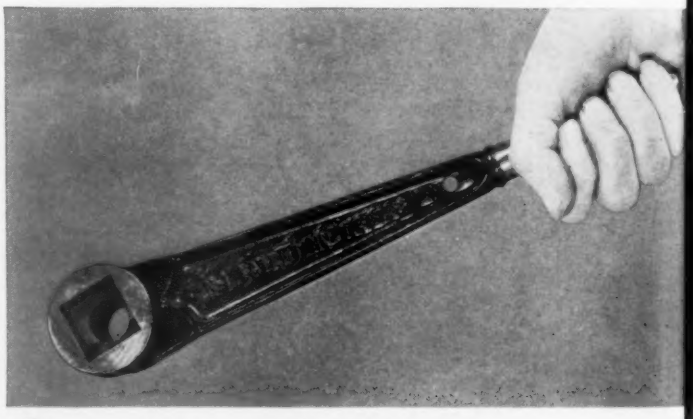


## 2 . . . ASSEMBLED ON PLAIN-END PIPE

● "Dressers" require no threading, drilling, grooving, nor reduction in wall thickness or strength; ideal for light-weight pipe; left-over lengths can be easily utilized. No damage to pipe ends during handling.

## 3 . . . BY UNSKILLED LABOR

● Inexpensive, unskilled labor, always near at hand, is used with "Dressers," eliminating the "human equation." Well-bunched crew is easily supervised; a mere handful of workmen needed.



## 4 . . . USING ONLY ONE TOOL

● With "Dressers" you need no complicated, costly machinery and equipment—which is not only hard to handle, but also expensive to operate, maintain, and transport.

## 5 . . . WITHOUT LOST MOTION OR LAG

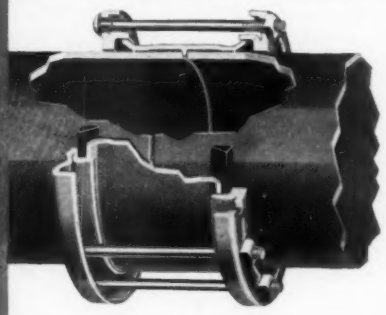
● Work moves forward in unison and without interruption on a Dresser-coupled line; no tedious alignment of pipe ends nor other slow joint-making operations hold up work; assembly practical from several points.

## 6 . . . UNDER ALMOST ANY CONDITIONS

● Snow, rain, ground-water, muck, swamps, etc., do not prevent making an "all-weather" Dresser joint; assembly is possible even under water, and/or in the dark, as on submerged line joined by diver.

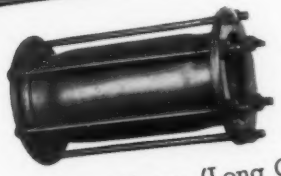
# your Pipe-Line Work!

(Cutaway view of Dresser Coupling, Style 38)



## *SIMPLICITY ...YES! ALSO:

1. PERMANENT TIGHTNESS—proved for 50 years, on 150,000 miles of pipe.
2. FLEXIBILITY—expansion, contraction, vibration, etc., are absorbed.
3. SPEED—typical examples: 4 min. for 5" size; 6 min. for 8"; 8 min. for 14" (two workmen).
4. STRENGTH—predetermined: joints safely withstand any specified pressure.
5. TRUE ECONOMY—a truly lower joint cost throughout life of line, plus salvage.



Dresser Long Sleeve (Long Coupling), Style 40, has longer body to span variations in space between pipe ends. Widely used for quick field hook-ups, closures, tie-ins, and cut-in work.

PIPE joints are the real "bottle-neck" of your pipe-line work. You know this if your own joint-making work has ever been held up by: (1) a single, slow operation; (2) dropping out of "key" workers; (3) difficulties in getting heavy machinery through swamps, etc.; (4) trying to supervise a crew spread out several miles; (5) delays due to wet ditches or bad weather.

You can get around all this by *simplifying* your joint-making operations!

With Dresser Couplings, most of the work is done before you start. All operations are standardized. Work goes forward uninterruptedly. You get "built-in" simplicity—which means *uniform*, fool-proof joints. Parts can go together in only one way—the permanently tight way! *Results:* all construction work is speeded up; costs are reduced; unforseen expenses, upset schedules, and uncertainties are eliminated.

For further details, write for our General Catalog No. 36, a virtual handbook on pipe joints. ● S. R. DRESSER MFG. CO., BRADFORD, PA. *New York:* 230 Park Avenue; *Chicago:* Peoples Gas Building; *Houston:* Shell Building; *San Francisco:* 1038 Polk Street; *In Canada:* Dresser Mfg. Co., Ltd., 60 Front Street, West, Toronto, Ontario.

# DRESSER

## PIPE COUPLINGS

well on June 19, 1936. This well, which was strictly a wildcat venture, was spudded in on April 23, 1936, and is located about 1,980 feet south and 660 feet east of the northwest corner of Section 26. Conductor pipe was cemented at 30 feet, 18⅝" casing at 580 feet, and 11¾" casing at 4,278 feet.

The top of the Emigh sand was encountered at 4,350 feet. The hole was carried down to a total depth of 4,485 feet, and 250 feet of 6⅝" 60-mesh Baash-Ross liner was installed. Shut-in pressure on the well stood at 1,725 pounds per square inch.

On a flow test, the well produced gas at the rate of 81,250,000 cubic feet per day through a 96/64ths inch bean, which reduced the pressure on the casing to 1,565 pounds, and on the tube to 1,550 pounds per square inch. With a 64/64ths inch bean, it flowed at a rate of 49,100,000 cubic feet per day with a tubing pressure of 1,670 pounds per square inch.

SECTION OF P. G. AND E. ELECTRICALLY WELDED 10" PIPE LINE ON ONE UNIT OF 60 MILE PIPE LINE SYSTEM TO DISTRIBUTE NATURAL GAS FROM THE RIO VISTA FIELD. AUGUST, 1937.

### Extent of Rio Vista Field

The limits of this field have not as yet been definitely defined. Two dry holes have been drilled on the northwest flank of the structure, Amerada Happe No. 1 and Standard Oil Neil Anderson No. 1. Some fourteen years ago a dry hole was drilled to a depth of 5,000 feet on a location about five miles east of the discovery well. Development to date has taken place largely on the northwesterly plunge of the structure. The northeast flank appears to be steeper and data thus far secured indicates some distortion in the formation. It appears that the gas-water interface occurs at approximately 4,400 feet below sea level.

At the present time there have been a total of twenty wells drilled in this field, eighteen of these being gas producers. It is estimated that approximately 6,000 to 7,000 acres have been proven, with an underlying gas producing sand of a maximum thickness of about 250 feet. This sand has a porosity of better than 35% and a very high permeability.

Three operators are now in the field, Amerada Petroleum Corporation, Standard Oil Company of California, and Tracy Development Company. The drilling thus far has included:

| *Operator* | *Producers* | *Dry Holes* |
|---|---|---|
| Amerada | 15 | 1 |
| Standard | 1 | 1 |
| Tracy | 2 | – |

The depths of the producing wells vary from 4,380 feet to 4,544 feet. Amerada drilled two deep tests, one its Happe No. 1, a dry hole, which was carried down to 7,029 feet, and the other its Margaret Hamilton No. 1 to 6,791 feet. Both of these wells were bottomed in the Cretaceous and apparently no oil was found.

### Quality of Gas

The natural gas produced from Rio Vista field is what is known as "dry gas" and is somewhat similar to that from other dry gas fields in California, except that it has a higher heating value.

Analysis of the gas produced from the Emigh #1 well shortly after its completion indicated the following:

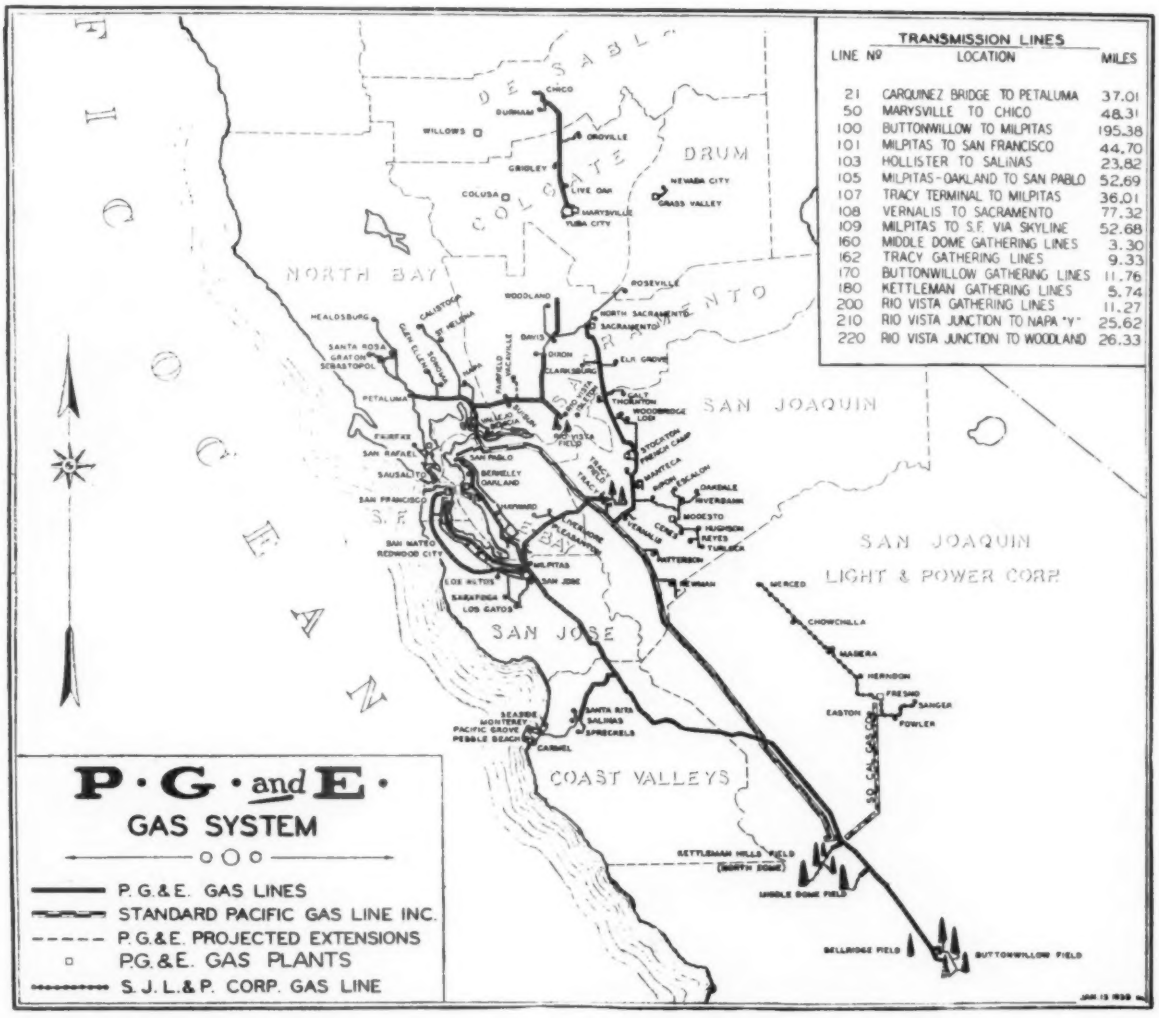
| | *June 19, 1936* | *Dec. 2, 1936* |
|---|---|---|
| $CO_2$ | 0.0 | 0.0 |
| $O_2$ | 0.0 | 0.0 |
| $C_2H_6$ | 4.7 | 6.0 |
| $CH_4$ | 93.6 | 90.0 |
| $N_2$ | 1.7 | 4.0 |
| | 100.0 | 100.0 |
| B. t. u. (Calculated) | 1,034 | 1,020 |
| Specific Gravity | .584 | .600 |

The following table sets forth the results of gas analyses made in April, 1937, of the gas produced from five of the Amerada well in this field:

| Depth of Well | *Emigh #1* 4,485 ft. | *Drouin #1* 4,500 ft. | *M. Hamilton #1* 6,791 ft. | *Mayhood #1* 4,533 ft. | *Serpa* 4,476 ft. |
|---|---|---|---|---|---|
| $CO_2$ | 0.30 | 0.50 | 0.40 | 0.20 | 0.10 |
| $O_2$ | 0.22 | 0.00 | 0.15 | 0.00 | 0.04 |
| $C_2H_6$ | 2.72 | 2.11 | 2.65 | 2.19 | 2.71 |
| $CH_4$ | 94.10 | 93.45 | 92.81 | 91.29 | 93.56 |
| $N_2$ | 1.70 | 3.10 | 3.10 | 5.10 | 2.70 |
| Propane | 0.78 | 0.68 | 0.72 | 0.85 | 0.72 |
| Iso. Butane | 0.04 | 0.06 | 0.03 | 0.18 | 0.05 |
| Butane | 0.11 | 0.08 | 0.09 | 0.14 | 0.08 |
| Pentane & Heavier | 0.03 | 0.02 | 0.05 | 0.05 | 0.04 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| B. t. u. (Calculated) | 1,023 | 1,002 | 1,006 | 1,005 | 1,009 |
| Specific Gravity | .588 | .590 | .594 | .600 | .588 |

By way of comparison, analyses of the gas from other dry gas fields are set forth below:

| | *McDonald Island* | *Tracy* | *Semi-Tropic* | *Buttonwillow* |
|---|---|---|---|---|
| $CO_2$ | 0.04 | — | — | 0.40 |
| $O_2$ | 0.08 | — | — | — |
| $C_2H_6$ | — | — | — | 0.30 |
| $CH_4$ | 96.12 | 91.85 | 98.70 | 99.30 |
| $N_2$ | 3.756 | 8.15 | 1.30 | — |
| | 100.00 | 100.00 | 100.00 | 100.00 |
| B. t.u. (Calculated) | 968 | 926 | 995 | 1,004 |
| Specific Gravity | .579 | .587 | .560 | .566 |


TRANSMISSION LINES
LINE Nº LOCATION MILES
21 CARQUINEZ BRIDGE TO PETALUMA 37.01
50 MARYSVILLE TO CHICO 48.31
100 BUTTONWILLOW TO MILPITAS 195.38
101 MILPITAS TO SAN FRANCISCO 44.70
103 HOLLISTER TO SALINAS 23.82
105 MILPITAS-OAKLAND TO SAN PABLO 52.69
107 TRACY TERMINAL TO MILPITAS 36.01
108 VERNALIS TO SACRAMENTO 77.32
109 MILPITAS TO S.F. VIA SKYLINE 52.68
160 MIDDLE DOME GATHERING LINES 3.30
162 TRACY GATHERING LINES 9.33
170 BUTTONWILLOW GATHERING LINES 11.76
180 KETTLEMAN GATHERING LINES 5.74
200 RIO VISTA GATHERING LINES 11.27
210 RIO VISTA JUNCTION TO NAPA "Y" 25.62
220 RIO VISTA JUNCTION TO WOODLAND 26.33
NORTH BAY
SACRAMENTO
SAN JOAQUIN
SAN JOAQUIN LIGHT & POWER CORP.
SAN JOSE
COAST VALLEYS
P·G·and E·
GAS SYSTEM
P.G.&E. GAS LINES
STANDARD PACIFIC GAS LINE INC.
P.G.&E. PROJECTED EXTENSIONS
P.G.&E. GAS PLANTS
S.J.L.&P. CORP. GAS LINE

It is interesting to compare the above with an analysis of the casing-head gas from Kettleman Hills Field where the gas is produced in conjunction with oil and passed through the gasoline extraction plants.

| | *Kettleman Hills Field* |
|---|---|
| $CO_2$ | Trace |
| $O_2$ | Trace |
| $C_2H_6$ | 7.80 |
| $CH_4$ | 86.51 |
| $N_2$ | Trace |
| Propane | 4.40 |
| Iso-Butane | 0.66 |
| Butane | 0.63 |
| Pentane and Heavier | Trace |
| | 100.00 |
| B. t. u. (Calculated) | 1,196 |
| Specific Gravity | .667 |

## Production

At the present time Rio Vista Field is producing in excess of 10,000,000 cubic feet of gas per day, of which about four per cent is consumed for field use and the balance for public utility distribution. The potential producing capacity of this field is, of course, very much higher than this and the actual production is limited to the market demand. It has been estimated that each of the eighteen producing wells would be capable of producing up to forty million cubic feet per day at present pressures.

The following shows the total monthly production of natural gas from this field since its discovery:

| *Month* | *Monthly Production —M Cubic Feet* |
|---|---|
| June, 1936 | 8,760 |
| July " | 11,205 |
| Aug. " | 27,051 |
| Sept. " | 15,251 |
| Oct. " | 6,803 |
| Nov. " | 12,311 |
| Dec. " | 19,698 |
| Jan., 1937 | 71,739 |
| Feb. " | 62,208 |
| Mar. " | 15,558 |
| Apr. " | 14,347 |
| May " | 18,628 |
| June " | 15,079 |
| July " | 13,864 |
| Aug. " | 11,410 |
| Sept. " | 86,838 |
| Oct. " * | 289,048 |
| Nov. " | 161,915 |
| Dec. " | 300,206 |

* *Initial delivery to public utility market.*

## Market

The principal gas distributing utility which serves central and northern California is Pacific Gas and Electric Company. This utility, together with its subsidiary San Joaquin Light and Power Corporation, annually sells some fifty-six and one-half billion cubic feet of natural gas to a total of 575,000 customers, the greater portion of whom reside in the San Francisco Bay area. About one-half of this gas is sold to domestic and commercial firm gas users, and the balance to industrials on a shut-off basis.

The other gas utility in the area is Coast Counties Gas and Electric Company, a subsidiary of Standard Oil Company of California, which sells approximately eight hundred million cubic feet of natural gas per year to a total of 10,000 customers located in Contra Costa County.

The greater portion of all of this gas is brought north from the Kettleman compressor station through two

*(Concluded on page 44)*

# STOP CAST-IRON JOINT LEAKAGE

## *the Inexpensive Way*

## with CARBOSEAL ANTI-LEAK

Trade-Mark

THE use of Carboseal anti-leak has become a routine procedure in the maintenance programs of over 200 gas companies. Many utilities have completely treated their entire distribution systems. Nation-wide experience indicates that the average cost of Carboseal anti-leak required per mile of 3-inch equivalent cast-iron main is under $100. Savings in terms of gas formerly lost have shown returns of 49 to 500 per cent on the investment.

Carboseal anti-leak corrects leakage in dry-gas distribution systems by permanently moistening and swelling the jute in cement or lead-caulked bell and spigot joints. Joints treated five years ago, and in contact with dry gas since then, remain 100 per cent tight on the soap test. Meter tests made on cast-iron mains, where no services were connected, showed complete elimination of leakage after Carboseal anti-leak treatment. Tests on mains with connected customers showed leakage reductions from 50 to 95 per cent after this treatment. In general, any remaining leakage was in the services.

From 2,000 to 5,000 feet of main a day can be treated without interrupting gas service. Carboseal anti-leak contains no volatile diluents which evaporate, and costs much less to apply than other lasting methods of stopping cast-iron joint leakage.

For further information write for Carboseal anti-leak bulletins which will be gladly sent without obligation.

CARBIDE AND CARBON CHEMICALS CORPORATION

*Unit of Union Carbide and Carbon Corporation*

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30 East 42nd Street, New York, N. Y.

PRODUCERS OF SYNTHETIC ORGANIC CHEMICALS

# Industrial Gas Heating Calculations

by

**Raymond F. Mann**

Wentz-Mann Company
Kenmore, N. Y.

In previous articles the relative merits of various gas burner systems have been described in some detail. Their capacities have been given and certain information as to their application. This month it is proposed to turn to the other side of the picture, the estimating of the gas demand that will be necessary for a specific installation and an examination of the available data that will be of help.

As a first step it is necessary to have a good background knowledge of combustion, and an understanding of the relationship existing between the products of combustion, their temperature, and the heat that they can furnish for useful work. It goes without saying that the industrial engineer knows the heating value, specific gravity, and pressure of the gas that he sells. This information will be requested by the manufacturer of burner equipment who receives his purchase orders. Still further, the gas analysis is often wanted, and occasionally such special data as the sulphur content or the moisture entrained in the raw gas. Of the highest importance, however, is a series of charts that give graphically the effect on efficiency of such items as excess air and excess temperatures.

If such charts are not available covering the local gas then the industrial engineer should draw up his own charts. He will find in the A. G. A. Booklet "Combustion" detailed instructions for doing this. The three figures given below are for a 900 Btu mixed gas and properly used answer any question on the combustion of that particular gas.

Efficiency is always the bête noire of the engineer and he must be in a position any time to determine and interpret furnace efficiency, either in answering a complaint on an existing furnace or starting up a new piece of equipment. Efficiency is, of course, the ratio of output to input. Often, however, it is difficult to measure output with accuracy. Hence we resort to that other definition of efficiency, namely the ratio of input less losses to input. In a closed furnace particularly, the determination of the losses is not difficult as there are but two sources, stack loss and radiation from furnace surface. With a properly insulated furnace the latter is

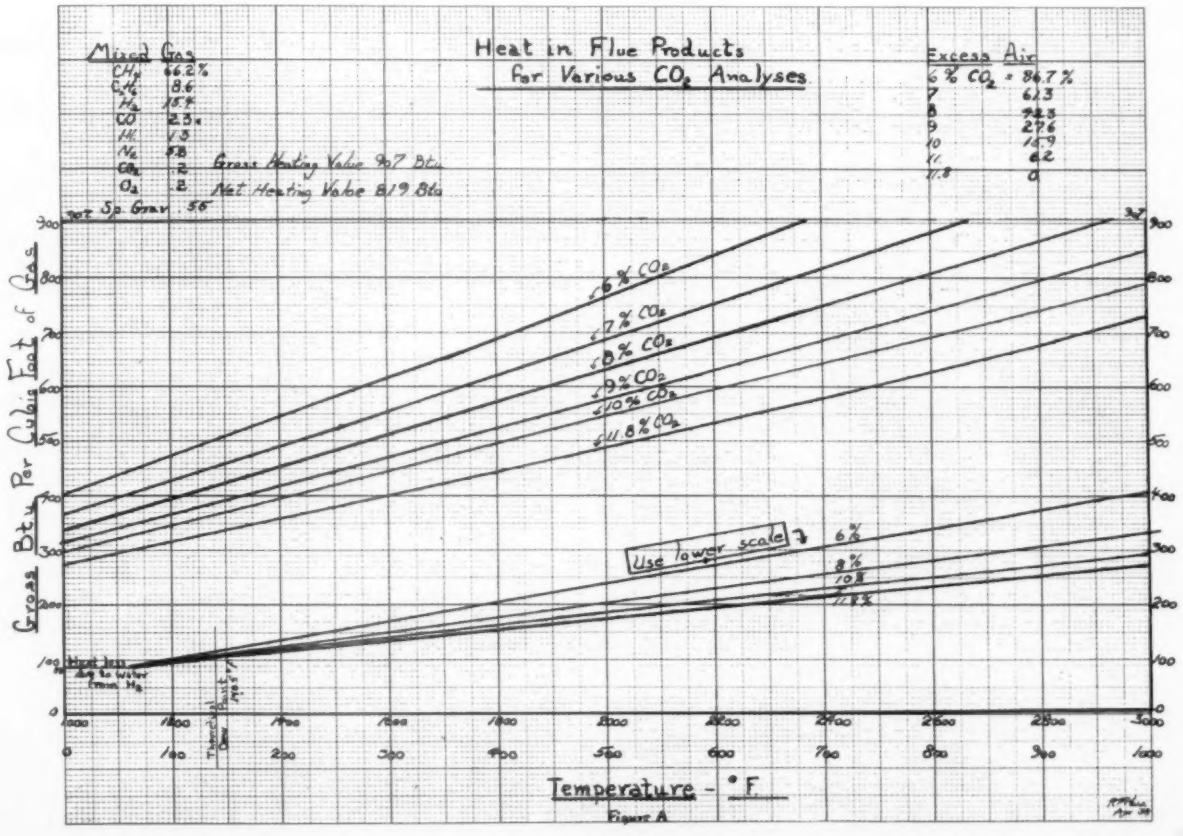



Figure A

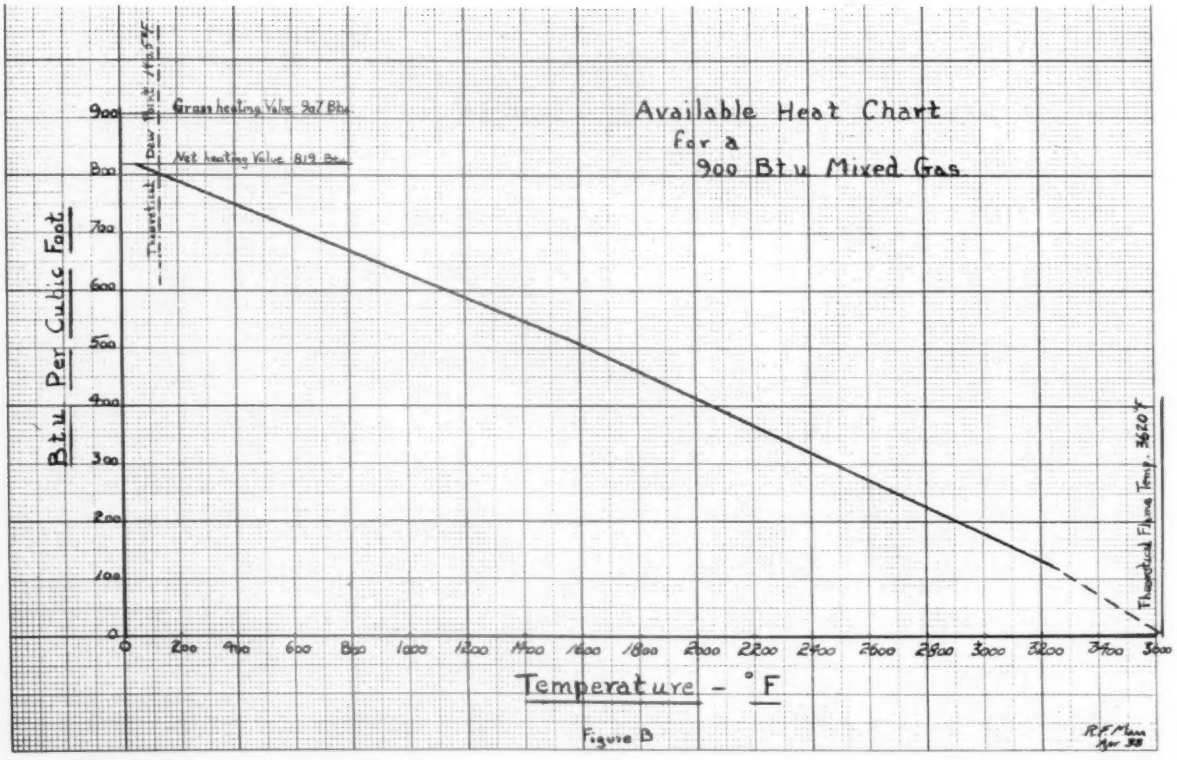



Figure B

kept at a minimum and rarely exceeds 5-10%. Therefore an accurate determination of the amount of heat leaving by means of the stack generally gives a sufficiently accurate picture of the efficiency.

A stack gas analysis means an Orsat or similar instrument for finding out the relative percentages of carbon dioxide, oxygen, and carbon monoxide in the hot waste gases. Reference to the chart then gives the percent of excess air and hence tells its story as to the efficiency of the combustion process itself. With burners of the atmospheric type an excess of air is necessary for complete combustion in accordance with the laws of mass reaction. An 8% $CO_2$ or a 40% excess air is considered reasonably good. With the low stack temperatures that prevail in furnaces where atmospheric burners can be used, such an excess air represents but a small loss in efficiency. When, however, we are dealing with furnace temperatures in the heat treating range or higher, it is essential to limit the excess air to an absolute minimum. Thus, at 500° F a 40% excess air represents a sacrifice of but 3.7% of the available heat, while at 1,800° F it means the loss of 27% of that available. With automatically proportioning burners it is easy to obtain and maintain the exact mixture of air and gas desired and, unless the work demands an oxidizing or a reducing atmosphere, the flue gas analysis should be that of a perfect mixture. Hence it is common practise in furnace design to base all calculations on perfect combustion and use the available heat chart (see figure B). If an oxidizing or a reducing atmosphere is necessary, only a small departure from neutral is permitted and the loss in efficiency is inconsiderable.

Analysis of the flue gas, however, does not give the complete picture. The temperature of the gases must be determined as well. The analysis may show a perfect mixture but if the stack temperature is several hundred degrees above the desired working temperature, obviously there is a sizable heat loss. Such a condition shows insufficient heat absorbing surface for the volume of gas being consumed, and indicates a faulty design. Hence a means of measuring temperature must be employed and will in general be a base-metal thermocouple (noble metal couples for the extremely high ranges).

Now knowing both analysis and temperature of the flue gases, reference to the charts quickly tells how close the furnace in question approaches the ideal. The ideal, of course, is the ultimate $CO_2$ combined with a temperature only perhaps 100° higher than the furnace itself. We realize that the stack gases must leave at a temperature somewhat above the furnace temperature (otherwise the gases would be heated by the work instead of vice versa). In a cold furnace the differential is quite wide but when up to equilibrium should be close to the figure just given.

This brings up the subject of available heat or the heat that theoretically can be utilized at any certain temperature. Obviously, the hotter the stack gases are when they leave, the less heat they can give up (the available heat) until the flame temperature of the gas is reached at which point no heat is available for outside work. Thus the available heat chart that we have drawn up (Figure B) automatically corrects the gas input for stack losses. For example, suppose we wish to heat steel stock to 1,600° F. Assume a stack temperature of 1,700° F. Then a 900 Btu mixed gas has an available heat at 1,700° F of 475 Btu per cubic foot. In other words the maximum efficiency possible (neglecting radiation losses) would be 475/900 or 52.8% *(An indictment, incidentally, of the common method of calculating efficiency. If we put 475 Btu's to work per cubic foot of gas burned we would be getting 100% of that possible, and if efficiency is a measure of our success in utilizing our raw materials, then we could with considerable justification claim 100% efficiency here).*

Expressing it another way, a demand of 1,000 Btu's to be furnished by a 900 Btu gas leaving a furnace at 1,700° F would require not less than 1,000/475 or 2.11 cubic feet of

gas. By the same token at 2,800° F it would require 1000/225 or 4.43 cubic feet of gas. This illustrates the problem of reaching extremely high temperatures and the reason for the low efficiencies (as we customarily figure them) of forging furnaces, brass furnaces, and the like. It takes 265 Btu to heat a pound of steel to 1,600° F and 450 to heat it to 2,700° F. Therefore, the amount of gas required to heat the steel to the higher temperature is 450/265 × 475/225 = 3.58 times as much as for the lower temperature.

Having now determined how much heat our fuel can supply under varying conditions let us turn to the estimating of the heat requirements of various operations. We quickly find that in any heating calculation three quantities must be determined, i.e.

A. The heat absorbed by the work.

B. The heat absorbed by the container.

C. The heat lost from the container during the operation. Considering these three factors in that order we will have.

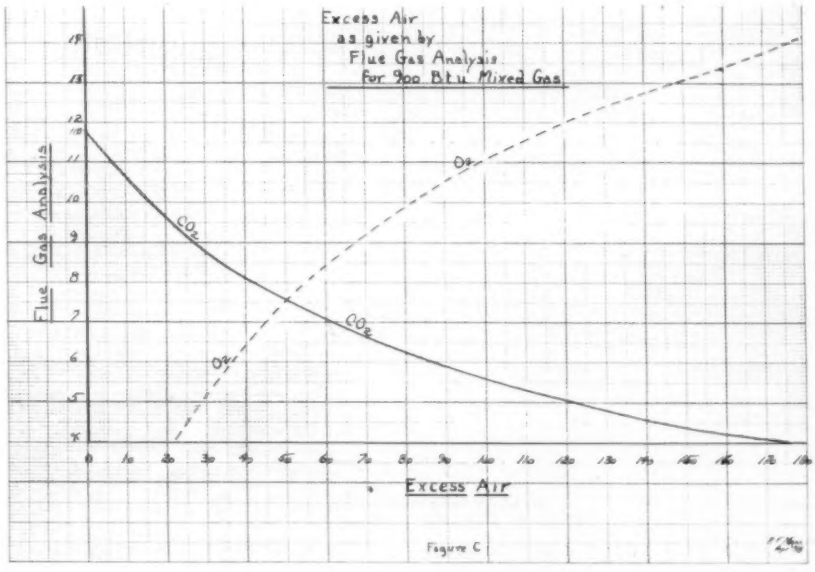
### Heat Absorbed By the Work

Fundamental laws of physics state that the heat required to raise the temperature of an object is the product of the weight by the specific heat by the temperature rise plus any latent heats of fusion or evaporation accompanying any change of state in passing through the desired temperature change.

The weight of the material should be one of the known factors in the problem at hand. It may perhaps be given in terms of volume, but nevertheless it is a definite quantity readily convertible into weight. Difficulties arise only when the quantity is a variable one. Such is often the case in drying problems. For example the drying of sand. The moisture content may vary widely from day to day and hence the heating demand. Drying problems in general lack a definiteness; and all the industrial engineer can do is to fix upon a maximum and design accordingly, being careful so to state in his proposal.

Knowing the weight of the material the next question is the specific heat. This should be available in some handbook of chemistry or physics. An excellent table is found in the A. G. A. Industrial Booklet "Steam Boilers," also in the A. G. A. "Combustion;" the Gas Engineers Handbook; the Chemical Rubber Company's "Handbook of Chemistry & Physics," and perhaps the most complete the "Smithsonian Physical Tables." Once in a while a certain specific heat is hard to find such as molasses (.6), bread dough (.65), and grease for the frying of foods. (.45). Parenthetically, the heat necessary to bake a one pound loaf of bread, including the heating of the pan, is approximately 235 Btu. Sometimes an assumption is necessary, in which case the specific heat of a similar substance is used. Thus, all aqueous solutions can be taken as 1. with little error, and all oils as app. .45.

The change of state that a solid passes through in becoming liquid, or a liquid in becoming a gas both demand heat even though there is a point at which the temperature remains constant. Iron in its solid state passes through a transformation point at app. 1,662° F where a similar addition of heat takes place without a temperature increase. Curves giving the heat content above 32° F in Btu per pound for the common metals help to simplify calculations. Such curves are found in the American Gas Catalog and Handbook, the Metals Handbook of the American Society for Metals, the Gas Engineers Handbook, and the Surface Combustion Corporation's "Industrial Burner Equipment Catalogue."




### Heat Absorbed By the Container

In general the determination of this factor is somewhat more difficult and often the subject of assumption. Of course where a pot holds the material and is underfired there is no problem. The weight of the pot is known or figured, its specific heat offers no difficulties, and its temperature is taken as that of the object being heated with little error. If, however, we are dealing with an oven furnace heated in any of the conventional ways, quite obviously the furnace walls vary in temperature all the way from that of the work down to nearly room temperature, the gradient depending on the wall thickness, material, and insulation.

It is true that tables exist giving the heat content and temperature gradient for many typical wall sections *at equilibrium*. The joker is in the last two words. With thick walls several hours even several days may be required to reach equilibrium. With a furnace intermittently operated it may never reach that condition. Hence we resort to rule of thumb methods. One method used where the furnace temperature will be reached slowly and the work held at temperature for some time, such as box carburizing or malleable annealing, is to assume that a 1" thickness of the firebrick walls will be heated to the required furnace temperature. Thus we multiply wall area in square feet x 1/12 x the weight per cubic foot x the specific heat of firebrick x temperature rise. This amount of heat is spread over the heating up period being added to that required by the work itself.

The other rule of thumb method used for smaller furnaces with a short heating up period is to neglect this factor altogether but to multiply the heat found necessary for the work plus that to make up the heat losses from the furnace by 1.5 in figuring what heat input to supply. This 50% factor of safety takes care of the extra load imposed by the heating up of a cold furnace and is adequate to supply whatever will be absorbed by the furnace itself.

### Heat Lost From the Container

As we outlined above, the greatest heat loss from the furnace is the stack loss but this is taken into account by means of the available heat conception, i.e. correcting the heating value of the gas for this loss at the start. Hence we are only concerned now with the radiation losses from furnace walls, from exposed surfaces, and from door openings.

Theoretical figures covering the heat loss through typical furnace walls are given in various books on furnace design but when applied to actual practise give results too low by as much as 50% in some cases. The reason for this discrepancy is probably because they do not make allowances for furnace leakage, door losses, etc.

The best figures available in the writer's opinion who has checked them many times are those given by the Surface Combustion Corporation in their Burner Equipment Catalogues entitled "Holding Consumption Curves." These curves have been based on actual furnaces and represent safe and accurate figures. They give in terms of cubic feet of 580 Btu gas the fuel consumption per square foot of wall area for holding a furnace at various temperatures. Note that the available heat of the gas has been used and hence to express these figures in terms of Btu's calls for multiplying the gas consumption by the available heat for that gas at the temperature in question.

To change to other gases it is accurate enough to multiply by the inverse ratio of the relative heating values. It will be noted that the flow of heat so obtained is at equilibrium conditions, a state that we have discovered may require several hours to reach. We always obtain this figure, however, using it directly in our calculations on furnaces with long holding periods and indirectly, in a rule of thumb method, for the typical, intermittently fired furnace as described above.

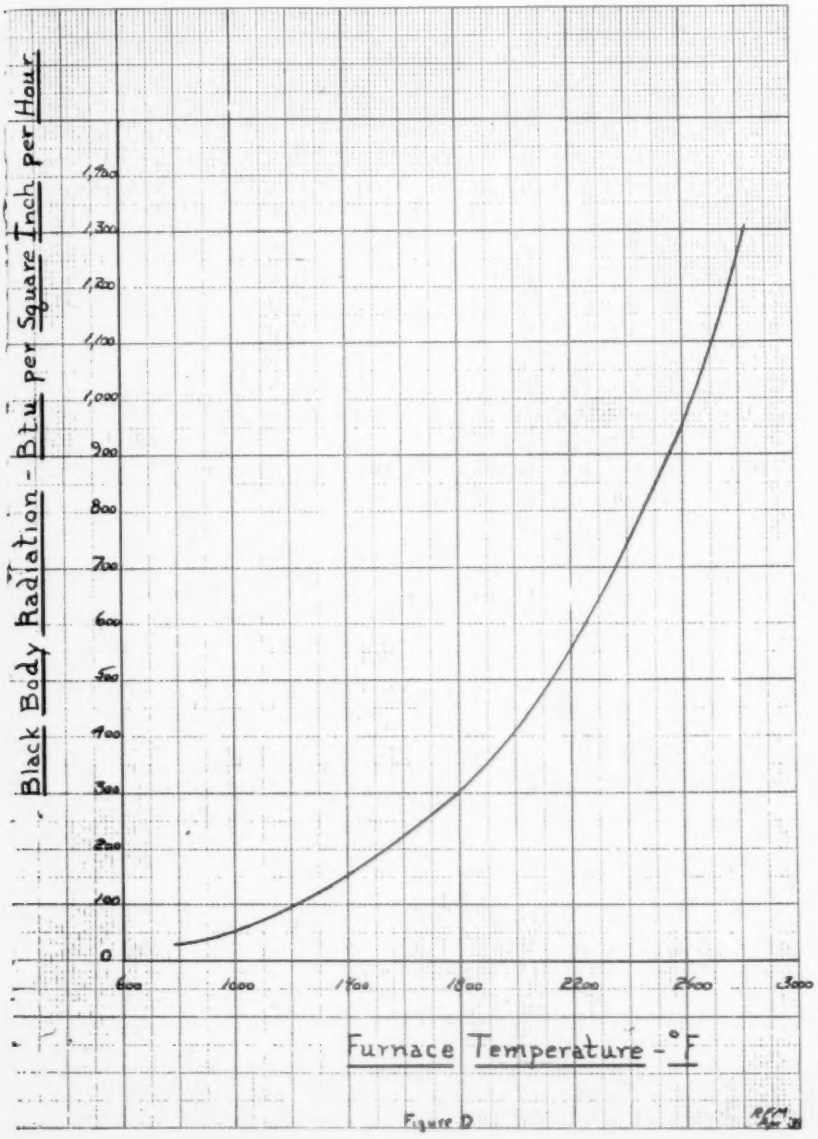


Figure D

For a closed furnace the heat loss through the walls makes up the entire loss (disregarding the stack loss) but if the furnace is operated with an open door or slot as with a forging furnace, then another loss is introduced. A close approach to such a door with forging temperatures of 2,200° F within gives adequate proof of the reality of this loss. For the same temperature of the interior the heat loss through the door varies with the thickness and with the size of the opening. We are dealing with radiant heat, an entity that travels in straight lines and is reflected or absorbed when it strikes a solid substance such as the brick or metal lining the furnace door.

If the door were of negligible thickness then virtually all of the radiant heat of an area equal to the door area would escape, but as we increase the thickness of the door opening and reduce the area, more and more radiant heat fails to escape. Hence in calculating door losses we use a "black body" radiation curve (see any standard handbook) correcting it for the door in question if the wall is thick, the area small and the need for accuracy acute. Thus at 2,200° F the black body radiation amounts to 550 Btu per square inch per hour. A slot 6" x 48" has an area of 288 square inches. Without correction 288 x 550 = 158,000 Btu per hour. Correcting first for the relative percent "black body," brick is .935, the figure becomes 148,000 Btu. If the wall is 4½" thick, the correction for the opening is .72, making the final result 106,600 Btu. As the gas input for such a forge would probably exceed 1,500,000 Btu's per hour, the two corrections have only amounted to three percent. Hence it is common practise to disregard all corrections and take the opening area as 100% "black body." *(For the engineer who is interested a table of door opening corrections appears in Mawhinney's "Practical Industrial Furnace Design," page 301.)*

Having covered the heat losses from closed furnaces we find in open kettles another source of loss, i.e. the loss by radiation from the bath or the molten work itself. Thus a galvanizing kettle, a lead pot, a stereotype furnace, all introduce this loss. Nor can this loss be disregarded. In a galvanizing kettle, for example, with

its large exposed metal surface and long holding periods (the zinc is always kept in a molten condition) the surface loss may easily equal one-third of the heat input. It is the recognition of this fact that leads to attempts at insulation such as covers of insulating material placed over the kettle when idle or the use of powdered insulating material on the surface of the bath itself. (The industrial gas engineer will, of course, recommend such steps wherever possible.)

The determination of the heat loss from a hot surface has been discussed just above. The "black body" curve (see Figure D) gives the radiation loss from the absolute "black body," and for accuracy should be corrected of the actual conditions at hand. Since, however, with the exception of polished metals or aluminum paint most ordinary materials have an emissivity of from .9 to .95 (black body is 1.0), the correction is small and generally disregarded.

### Typical Example

In order to illustrate the use of the principles given above, an actual example covering the calculations necessary for burner design for a salt bath used for the annealing of wire follows:

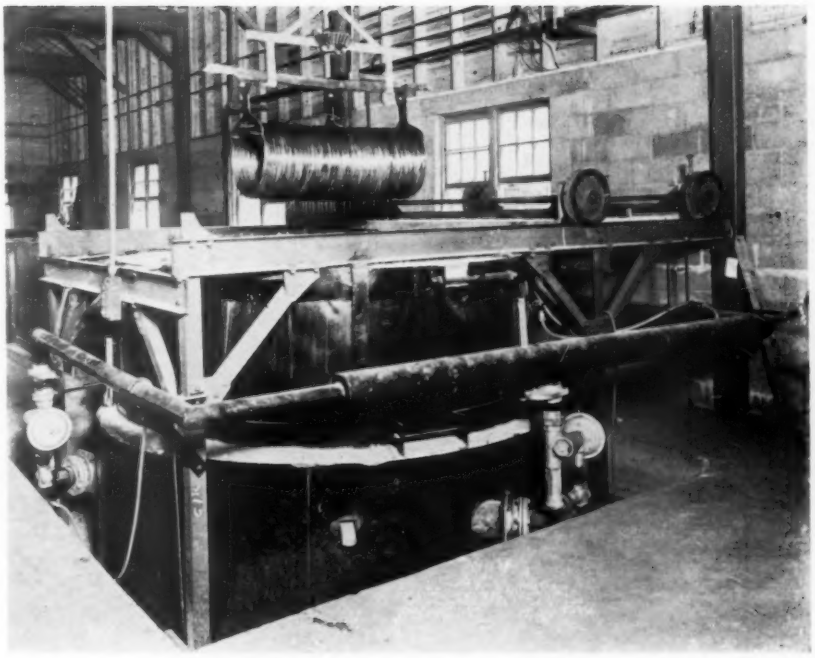
Problem:—To heat 1,200 to 1,500 pounds of steel wire in coils per hour at a temperature of from 1,320-1,450° F in a salt bath, the pot being 4′3¾″ in diameter by 3′8″ deep and ¾″ thick. The pot to set in a round casing with walls of 9″ firebrick plus 4½″ of sil-o-cel brick as shown in Figure E. (We hold no brief for the casing design. The plant manager wished to duplicate a satisfactory furnace in some other city.)

Realizing the terrific heat loss from the bath surface, 42% of the total, a cover of 4½″ fire brick was so arranged as to roll over the pot as soon as loaded. Correcting the above for this change the heat loss from the surface becomes

$$\frac{2123}{144} \times 8 \times \frac{580}{900} = 76 \text{ cubic feet}$$

and the total output 802 + 318 + 76 = 1196 cubic feet.

This furnace was built in 1935 using three tunnel burners firing tangentially around the pot, fed by three low pressure inspirators sets of the automatically proportioning type and is in successful operation today. It is interesting to compare the actual operating results with our calculations above.



**Gas Fired Salt Bath for Annealing Wire**

### Calculations

Heat absorbed by the work $\dfrac{1{,}500 \times 235}{440} = 802$ cubic feet

*(1,500 is the maximum weight of steel. 235 is the heat content of steel at 1,450°F., the maximum temperature. 440 is the available heat of our 900 Btu mixed gas at 1,850°F., the assumed stack temperature.)*

Heat absorbed by the pot
Heat absorbed by the furnace walls — As this furnace operates on a continuous cycle, 24 hours a day, these data are unnecessary.

Heat lost from the furnace — Wall diameter 5′10″ = 18.3′ circumference.
18.3 × 5.7 = 104 sq. ft. vertical wall.
Area of 4½″ tile around top = 12.5 sq. ft.

$104 \times 3 \times \dfrac{580}{900} = 201$ cubic feet

$12.5 \times 14.5 \times \dfrac{580}{900} = 117$ " "

Total thru wall 318 " "

*(3 and 14.5 are the cubic feet of 580 Btu. gas per square foot of 9″ fire brick + 4½″ sil-o-cel and 4½″ fire brick walls respectively holding loss at 1850°F.)*

Heat lost from the surface of bath $\dfrac{2123 \times 170}{440} = 820$ cubic feet

*(2123 is the area in sq. in. of the 4′4″ diameter pot. 170 is the black body radiation loss per square inch at 1450°F.)*

Total output at operating temperature — 802 + 318 + 820 = 1,940
Estimated burner demand — 1,940 × 1.5 = 2,910 cu. ft.

*(The maximum consumption while working would be 1,940 cubic feet. By rule of thumb we multiply this figure by 1.5 in figuring burner capacity, thus taking care of the extra load in starting up a cold furnace during which time the pot and the walls of the furnace are absorbing heat.)*

---

Running at equilibrium with a production of 1,200 pounds per hour, the gas consumption was 960 cubic feet. Correcting our heat absorbed by the work for this lower output our figure becomes 642 + 318 + 76 = 1,036 cubic feet, less than 8% off and that on the safe side. Likewise the actual holding consumption at a temperature of 1,100° F was 240 cubic feet. The holding loss at this temperature is approximately 59% that at 1,450° F and 59% of 318 + 76 is 233 cubic feet, a re-

markably close check.

As a final word, warning should be given that the methods of calculating gas consumptions discussed in this article apply only where the hot products of combustion furnish the necessary heat. This is the case in the great majority of heating operations. When, however, the heating is to be done by circulating or recirculating hot air certain additional calculations must be made and as this is a subject by itself it will be left for future discussion.

The fundamentals for both methods have been given and a little study will show that their application is neither complex nor confusing. Occasionally an assumption has to be made but a little practise and a little engineering common sense quickly fills that gap.

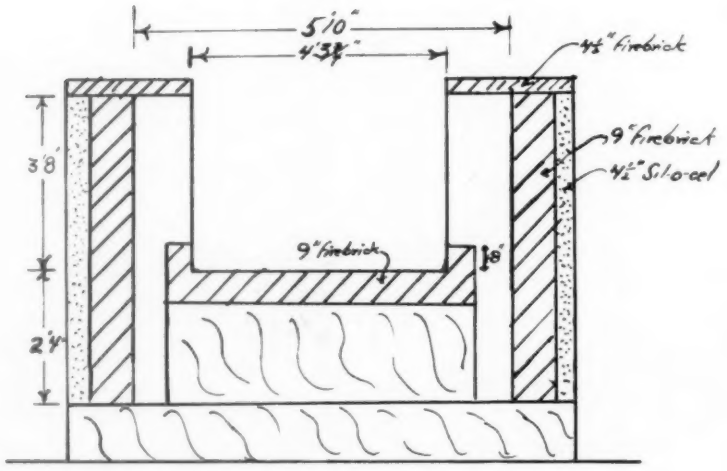



Figure E

## Welcome To Salesmen

At the Chattanooga home office of the American Lava Corp., a letter is posted just inside the entrance and at the stairway of a three-story building where the offices are on the second floor. The letter is headed "Welcome to Salesmen and Other Callers," is signed by the President, and reads as follows:

"Bearing in mind that when our own sales representatives call on our customers and 'prospects' we expect them to be accorded a courteous hearing, we desire to afford one to you.

"Whatever your errand, unless you wish to discuss politics or strikes, this company expects you to be greeted politely, pleasantly and promptly by everyone with whom you come in contact here. When time is short or callers numerous the usual preference will be shown those from out of town.

"If you have something to sell which does not fall in the usual channels of a purchasing department, ask at the information desk to the left at head of stairs. Please go there first anyway. Thank you for your call. We hope it may be profitable to us both."

## Manning, Maxwell & Moore, Inc. Reports to Jobholders

Manning, Maxwell & Moore, Inc., with plants in Bridgeport, Boston, Muskegon and Jersey City, recently struck a new note in "industrial democracy." In a local auditorium the thousand-odd employees heard their president, Robert R. Wason, present a detailed report covering the company's operations during the past year.

All facts were presented with complete frankness. With some 60 animated lantern slides, Mr. Wason went into every phase of the operations of the company, which does an annual volume of approximately ten million dollars in the production and sale of industrial equipment including gauges, valves, locomotive and railway equipment, cranes and hoists, precision instruments and mill supplies.

In conclusion, speaking on general conditions, Mr. Wason said he felt that the business outlook was inherently by no means as dark as it is sometimes painted. "What business needs today is a chance to settle down and go to work," he said.

## A.S.H.V.E. Summer Meeting

The tentative program for the summer meeting of the American Society of Heating and Ventilating Engineers, to be held at The Homestead, Hot Springs, Va., June 20 to 22, just announced, lists ten technical papers and an extensive program of entertainment comprising golf and tennis tournaments, sightseeing trips, concerts, bridge and dancing.

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# Pipe Corrosion & Coatings

## Types of Coatings—Asphalts

### Part 23

**By Erick Larson**

#### Definition

ASPHALT pipe coatings are corrosion protecting materials whose basic ingredient is a native or natural asphalt or a bitumen secured through the distillation of certain petroleum or crude oils. The latter is sometimes called a residuum asphalt. Natural asphalts are those which exist in nature in a state which may be directly used for water proofing purposes including pipe coating without distillation or purification. Natural asphalts are secured from such sources as the Trinidad beds.

The term asphalt does not designate any particular combination of ingredients but merely that the source of the basic material was petroleum or natural asphalt. Natural asphalts are usually designated by the word "natural" although they may be included in the general term. Refining methods produce asphalts of widely varying characteristics and in combination with other materials, asphalt compounds having innumerable characteristics are manufactured. Therefore, the failure of any one combination as a corrosion protectant can not be used to condemn asphalts in general. The same refining methods applied to apparently similar raw material but from different sources do not always produce the same characteristics in the finished product.

Asphalt base coatings may be sub-divided into such forms as paints, emulsions, coupling compounds, mastics and enamels. Paints have been described previously.

#### Asphalt Emulsions

Asphalt emulsions are a liquid (water) phase in which the asphalt is dispersed through an emulsifying agent. The use of water as a vehicle eliminates the necessity for solvents in preserving the state of fluidity. A stable emulsion can be formed with asphalt and separation is therefore not a factor previous to application. An emulsion coating is applied cold and as the water, which is the vehicle, evaporates the material becomes stiffer. Instances of failure of asphalt emulsion pipe coatings even in mildly corrosive soils, have been experienced. The failures have been widely spaced geographically. Failure has also occurred where chromate inhibitors have been incorporated in the asphalt emulsion. Ordinary shielding extends the period of usefulness but generally not to the extent that shielding protects tar base enamels.

A shield has been formed on asphalt emulsions by sprinkling dry Portland cement over the surface. The water rising to the surface produces a neat cement which becomes hard with aging. Such a shield has some tendency to retain the emulsified condition at least in a partially saturated condition for a longer period than more previous shields. However, this type of shield is more susceptible to the physical destructive forces surrounding pipe lines than the thicker and more flexible type of shield in most common use. Application of an outer layer of emulsion over the shield extends the period of protection but is costly when compared with equivalent success with other types.

There have been instances where unshielded emulsions have been reported as successful in actual practice. Actual research programs conducted by investigators also familiar with operating conditions have not substantiated the reported instances of success.

The low di-electric strength of asphalt base emulsions is partially responsible for a lack of resistance to corrosion. The vehicle is water and evaporation frequently results in a high degree of porosity. The original water may be displaced or replaced by liquids producing a greater rate of corrosion. Exposure to the sun previous to burial causes a rapid evaporation of the vehicle and contraction has been observed of a sufficient amount to produce cracks penetrating to the metal. Modern manufacturing processes have made it possible to produce the same degree of desired flexibility in tar as in asphalt base enamels.

An important cause of emulsions failing being the evaporation of the water, it would appear desirable to experiment with an impervious wrapper. Such a wrapper may have the effect of retaining the water vehicle indefinitely. The stable nature of the emulsion and the fine dispersion of the water particles would minimize the effect of some water being in contact with the metal. The success of such a wrapper would make it possible to take advantage of such characteristics as ease and simplicity of application, application in damp weather or moist conditions, no need for a primer and flexibility. An important consideration will be the degree to which dehydration will be necessary, if at all, before the wrapper seal should be applied.

#### Natural Asphalts

The natural asphalts warrant mention because of their use as water-proofing agents through many centuries. Natural asphalts would not be included in the category of enamels unless specially prepared and such preparation has been more experimental than extensive. The earliest records of the use of bitumens is generally traced to the pre-Babylonian inhabitants of the Euphrates Valley about 3000 B.C. Each civilization since that time has recognized and used the preserving properties of bituminous materials as found in a natural state.

The sealing qualities of the natural bitumens are illustrated by the perfect state of preservation of the bones of pre-historic animals removed from the La Brea pits of California.

The native or natural bitumens contain various undesirable impurities or lack certain characteristics which are desirable in sub-surface pipe protection. The preservation of bones is largely attributable to the considerable thickness of the asphalt surrounding the skele-

ton. The longevity of other materials protected by natural asphalts results from exposure to atmospheric conditions only. Sub-surface structures require an uneconomically thick coating for adequate long term protection.

### Coupling Compounds and Mastics

Coupling compounds and mastics in all types of hot applied coatings are basically the same as the enamels except for being in a fluid or mastic state at ordinary temperatures. The fluid or mastic state is produced by the use of solvents, the degree of fluidity being dependent on the quantity of solvent used. Those in the fluid state may be applied by pouring, painting, spraying, wiping or belting. The mastics are applied by hand, trowelling or other methods which will result in the putty like substance being firmly pressed against the pipe at all points. Both the coupling compounds and mastics depend upon the use of vehicles or solvents which later evaporate. The effects resulting from evaporation of any portion of a pipe coating has been previously indicated as undesirable.

The fundamental reason for the use of coupling compounds and mastics is ease of application. The fundamental reason for pipe coating, being protection from corrosion, the use of coupling compounds and mastics results in the sections of main where they are applied having less potential life than those portions protected by a hot applied enamel. The higher cost of applying the known superior protection over the whole surface if used on any part is therefore warranted. The general trend has been away from the use of coupling compounds and mastics.

### History of Asphalt Enamels

Asphalt enamels originated in the marine industry where they were used for the corrosion protection of the interior surfaces of ships, dry docks, caissons, etc. They were used in foreign countries, notably England, for a considerable period before being introduced into this country. Except for experimental use, asphalt enamels were first extensively applied to western U. S. oil and gas lines in 1909. The penstocks of the Panama Canal locks were protected by a hand brushed asphalt enamel applied in 1912. In 1913 and 1914 two thousand feet of 66″ diameter steel water pipe was externally coated by the City of New York. From 1917 to 1930 the popularity of asphalt enamels for the protection of oil, gas and water lines gained rapidly.

### Availability of Asphalt Enamels

Petroleum being the basic material from which asphalt enamels are secured an adequate supply is assured for a long period. The price while downward over a long period in the past will fluctuate with petroleum and will rise as the sources of petroleum become depleted and as refining methods convert larger percentages of the crude material into the gasolines or products bringing a higher rate of return.

### Ease of Application

Asphalt enamels are in a class with other types of enamels considering application. The care necessary in preparation of the pipe, priming, heating of the enamel application, and wrapping result in enamels of any type being the most costly of the more common coatings. While no high degree of skill is required, care beyond that for other types is necessary when applying enamels. The superiority of enamel coatings warrants thorough consideration of the extra cost resulting from their use.

### Physical Resistance

The ability of asphalt enamels to resist shock, abrasion, compression and other physical forces encountered previous to burial depends upon such properties as hardness, toughness, etc. These properties may be varied by the amount and type of filler used and the processing of the petroleum. Commercial asphalt enamels require avoiding any excessive shocks, concentrated blows or intensive pressure. Asphalt enamels of 180 degree F. melting point or above possess sufficient strength to be handled as previously mentioned for enamels, unless the melting point is so high that unusual brittleness results. Asphalt enamels with a melting point less than 180 degrees F. are usually sufficiently soft to compress under the weight of the pipe if stored for any long period of time.

### Temperature Effects

The effect of temperatures on asphalt enamels corresponds to the effects mentioned in the general discussion of temperature effects. In northern sections of the United States and in Canada minimum melting points of 190 degrees F and in the southern sections 200 to 210 degrees F are desirable to avoid having the asphalt enamel flow when exposed to summer suns.

### Bond

The bond between hot applied asphalt enamels and the metal depends upon the cleanliness of the metal, the use of the proper primer, dryness of the primer, age of the primer after application, cleanliness of the primer surface, heat of enamel application and the proper application of the coating. Ordinary care to assure that the above factors are adequately provided for, will result in a bond possessing the necessary strength. The tendency in the past has been to manufacture asphalt enamels of a comparatively low melting point which are less difficult to bond than the more brittle higher melting point types. The adequacy of bond may be practically demonstrated by striking the enamel with a blunt instrument. The area of cleavage between pipe and enamel should not extend for more than a fraction (¼″ approximately) of an inch beyond the edge of the striking surface of the instrument.

### Thickness

The minimum thickness for a single layer of an asphalt enamel having a melting point in excess of 180 degrees F. whether protected by a shield or not should be 5/64 of an inch. A tolerance below 5/64″ may be allowed if the protection is shielded but should not exceed 10%. There is no particular advantage in a thickness in excess of 5/64″ and a maximum of ⅛″ is desirable. Thicknesses above the minimum are apt to increase brittleness and do increase susceptibility to damage from shock.

The thickness of the lower melting point and more ductile asphalt enamels is usually increased so that a 160 degree F. enamel would be 3/32″.

There are instances of specifications requiring thicknesses considerably above the minimum of 3/64″ such as that given by Ulric B. Bray and Frederick S. Scott of the Union Oil Company of California which was as follows:

| | |
|---|---|
| Melting point (B + R) °F | 190—200 |
| Penetration at 32°F (200 gr.—60 sec.) | 20 minimum |
| Penetration at 77°F (100 gr.— 5 sec.) | 30—40 |
| Penetration at 115°F ( 50 gr.— 5 sec.) | 75 maximum |
| Ductility at 77°F. | 2 cm minimum |
| Ductility at 32°F. | 1.75 cm minimum |

Estimated quantity required per 100 square feet of pipe surface, 3/32 in. thick 500#.

That specifications on asphalt enamels vary although producing practically equal results is evident when comparing the following as given by Lee Holtz at the 1936 A.G.A. Distribution Conference.

1. One coat primer on sandblasted pipe
2. One coat asphalt, 175° melting point, 20 normal penetration, 4.5 ductility
3. Two wraps cellulose base paper
4. One coat asphalt same as #2
5. One wrap Kraft paper

The companies producing petroleum continue to use large quantities of asphalt enamels and usually recommend the extra heavy minimum thickness of 3/32". The recommendation of such a practice may be somewhat influenced by the relationship between the producer of the raw product and the basic ingredient of the coating. Companies having oil fields usually place a considerably lower desired life on gathering and pumping lines than distributors of gas and water. Petroleum producers would ordinarily be satisfied with a shorter life of pipe whether coated or uncoated than other users of sub-surface pipe. Circumstances therefore, alter the economics and in some instances even no protection is justified.

### Soil Stress

Enamels have been demonstrated to require a shield as soil stress has been observed in every type of soil. Providing melting points of 210 to 220°F. melting point have not materially improved the resistance of asphalt enamels to soil stress. The use of so-called tough lower melting point enamels developed for the interior surface of water piping has not improved resistance to soil stress. While these tougher enamels may provide more tenacity of bond they do not provide any more if as much resistance to the many physical forces causing deterioration. It was previously suggested as a general rule that a shield is also desirable on asphalt enamels.

### Absorption

Asphalt enamels absorb more moisture than other hot applied enamels. The reason for high absorption may be the loss of oils or drying action which is a particular characteristic of asphalt dehydration. Porosity gradually increases in asphalt enamels with age.

### Dehydration

The loss of oils and a method of prevention is explained in a paper by D. R. Hiskey presented before the Pacific Coast Gas Association in June 1936 from which the following is an extract.

"Those who have examined pipe lines treated with asphalts have noticed that after a comparatively short period of time the outer surface of the asphalt becomes dull, having lost its gloss, and upon continued exposure becomes brittle and will pulverize when rubbed between the fingers.

An extensive study has been made recently by the Southern California Gas Company of its mains and services, particularly the condition of the outer layer of asphalt. Careful records have been kept of the kind of material used in protection, together with the dates of installation. In the past few months several series of inspection have been made to study the cause of this rapid deterioration of the outer asphalt layer and means of producing a remedy for this failure.

The source of supply of our asphalt comes from crude oil. All are more or less familiar with the details of refining and these will not be discussed here. Our present-day asphalt can be said to be composed of a bitumen and an oil. It is now reasonable to conclude that when such a product is put in contact with soil some action is going to take place. In a sandy or sandy-loam soil we know that a capillary attraction is set up by the soil and that these oils, incorporated with the bitumen, will be drawn out and enter the soil. A good example can be found on any roof so coated with asphalt. The sun beating down upon this roof will draw out a larger percentage of the oils, leaving the residual bitumen dry and with little or no life left. This same action, no doubt, occurs in our sandy soils and to a lesser degree, in our heavier type soils. The rate at which these oils leave the bitumen depends on local conditions.

One particular pipe line I have in mind has been buried since April, 1932 and is in a very sandy soil with a corrosion index of .550 by our nipple and can method. The outer asphalt layer is approximately 1/32 of an inch thick. This coating will pulverize when rubbed between the fingers. Visual and microscopic examinations reveal the oils to have practically disappeared.

With these facts in mind, several tests were started in our laboratory to determine some means of preventing these oils from being leached out by the soil. It is the common practice of the major oil and gas companies to apply a wrapping of kraft paper over the outer layer of asphalt, primarily for the purpose of removing stickiness of the asphalt and to locate damaged places which might be repaired during the course of construction. The kraft paper has no protective value itself and soon disintegrates after burial.

In a series of laboratory tests, pipe nipples were treated with our standard coating and placed in small test boxes for accelerated corrosion tests. Over some of these was applied our new cellulose wrapping material. The test was allowed to run approximately 90 days after which time they were removed and examined. Those coatings not protected by the cellulose material showed definite signs of deterioration of the asphalt and also, signs of soil stress. The outer asphalt layer had become dulled to a depth of about 1/64 of an inch. A melting point determination was made and with an initial melting point of 185 degrees F. it had increased to 208 degrees F. in the 90 days. Those specimens having an outer layer of cellulose remained bright and glossy, the only evidence being slight soil stress marks with no evidence of moisture present, against the asphalt. The melting point of the asphalt had remained the same as the initial one.

In order to try and produce some visible means of watching the leaching action of the oils by the soil or some other material, small asphalt buttons were cast and placed upon small squares of white blotting paper. These were weighed and placed in covered containers. After three weeks' time five of the eight squares of paper had definite rings of a dark colored substance resembling a heavy oil. Those which showed no discoloration were covered by a filled asphalt enamel. These tests are being carried on to study just what rate these oils leave the asphalt.

These tests are still in an experimental stage, and we feel that with careful field inspections of operating lines to which have been applied high melt enamels and cellulose wrappers in place of the kraft paper, that by increasing the life of the outer asphalt layer we will also increase the life of our pipe. No doubt, as the oils are leached out they must be replaced by something else which is moisture and thereby the water-proofness of our asphalt is reduced materially.

At the present time two methods are available to reduce this leaching first, by the application of some

water-proof material in place of the kraft paper and second, by the use of a filled asphalt enamel. By using some inert material as a filler such as diatomaceous earth in which the attraction between the filler and oil in the asphalt is greater than that between the oil and the soil, a reduction in loss of the oil in the asphalt is had. This is particularly true in the case of the high melt enamels."

### Dielectric Strength

The initial dielectric strength of practically all asphalt enamels is sufficient for conditions ordinarily encountered. The comparatively rapid increase of moisture content causes a decrease in the dielectric strength. Asphalt enamels lack stability and the loss of dielectric strength is one of the first indications of the gradual breaking down.

### Toxic Properties

Asphalt enamels are not toxic to plant life or bacteria. Therefore, it is not uncommon to find plant roots penetrating such enamels. Bacteria have not been recorded as far as the author knows as having existed or thrived in asphalt enamels.

### Fillers

Fillers are used in asphalt enamels for the reasons previously enumerated in the general discussion of enamels. A more detailed study of fillers for asphalt enamels than has been carried on to date may indicate certain ones possessing the desirable property of retaining the oils and thus minimizing the loss of volatiles. The quantity of fillers varies up to 40% with some experiments extending beyond that quantity.

### Effect on Other Coatings

Asphalt enamels do not affect the properties of other coatings and in turn are not affected by them. This does not mean that other coatings will prevent the gradual loss of protection value frequently found occurring with asphalt enamels. The coating of an asphalt enamel with any other coating may lengthen the period of protection.

### Uniformity

The processing of asphalt enamels and the procedure control for application have been developed to a state where uniformity of the material either in the various parts of a single drum or between widely separated shipments is possible. The variableness with which asphalt enamels can be produced suggests the desirability for frequent checking. The most generally used check, because of the rapidity and ease with which it may be made, is the melting point. Others prefer to test the penetration or ductility. All are indicative and experience with any soon facilitates accuracy of interpretations.

Using the ring and ball method a variation of more than 5°F± while rather unusual in a standard product would not warrant rejection. Any variation of more than ±10° would warrant rejection or at least ascertaining that all other qualities were satisfactory. While the melting point may be indicative, care should be taken not to place too much weight on this or any other one factor.

Asphalt enamel removed from a line any considerable time after application is more apt to vary in melting point or in any other test than other commonly used coatings. This fact precludes comparison of tests made on asphalt enamels after being in service with a new product. If the original qualities of an asphalt enamel are known it may be expected that a new product possessing similar characteristics will react the same in service.

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## Rio Vista Gas Field

*(Continued from page 33)*

main transmission lines, each approximating 210 miles in length, one of which is the 26″ Stanpac line owned jointly by Pacific Gas and Electric Company and Standard Oil Company of California, and the other a 20″ line owned by Pacific Gas and Electric Company.

The transmission network contains nearly 1100 miles of line and gathers gas from Semi-Tropic, Buttonwillow, Kettleman Hills, Tracy, McDonald Island and Rio Vista fields.

The demand for natural gas in the area involved is continually increasing and the two main transmission lines above described have been almost continuously loaded to capacity during the past two years.

### Pipeline Connections

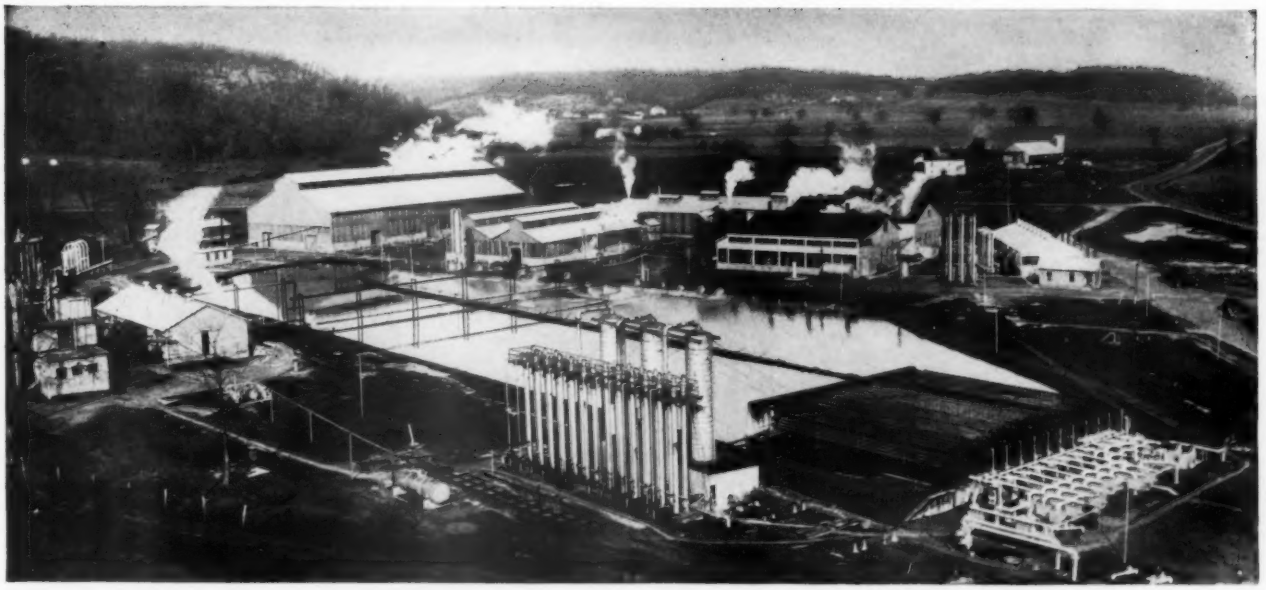
In order to take the Rio Vista gas into its system, Pacific Gas and Electric Company laid a 12″ line from the field in a northwesterly direction, a distance of 5¾ miles to a point southeast of the town of Dixon and due east of the cities of Fairfield and Suisun, in Solano County, and from said point a 10″ line, in a westerly direction, a distance of 26 miles to a point in Napa County near the Napa "Y," connecting with its existing 12″ line between Vallejo and Petaluma; also, from the end of the 12″ 5¾ mile line, a 10″ line due north a distance of 14½ miles to a point due east of the town of Dixon, where it connects with the existing 6″ line running from Dixon to Davis; and an 8″ line due north a distance of 12 miles to a point about 2 miles north of Woodland, in Yolo County, to the Spreckels Sugar Company's beet sugar plant.

The cost of this project was in the neighborhood of $900,000.00 and its gas carrying capacity is estimated to be approximately fifty million cubic feet of gas per day.

As will be noted in the accompanying map, the installation of these new lines forms a loop connection between Pacific's Sacramento line and the main feeder line to its North Bay Area, thus making it possible to feed gas either way, greatly increasing the flexibility of operations in meeting heavy demand or emergency conditions.

The locations of the new Rio Vista and McDonald Island gas fields, situated as they are at the northern end of Pacific's extensive transmission system, are very advantageous to that utility in furnishing additional and substantial sources of supply in the immediate neighborhood of its largest market, thereby relieving, to some extent, the two long transmission lines from Kettleman and Buttonwillow.

Not only that, but they provide a valuable and immediately available standby source of supply in cases of extreme demand or emergency shutdown of either one or both of the main transmission lines from the south.



*Crawford Compressor Station of the Ohio Fuel Gas Company at Sugar Grove, Ohio . . largest in the world. It is one of the 104 Columbia compressor stations with a combined capacity of 209,911 h.p.*

# MEETING THE GAS NEEDS OF A HIGHLY DIVERSIFIED MARKET

THE service territory of Columbia System is a populous area comprising adjacent sections of Ohio, Indiana, Kentucky, West Virginia, Virginia, Maryland, Pennsylvania and New York. To that large market gas is made readily available for the varied requirements of industry as well as commercial and residential purposes. Continuing demand for this dependable and economical fuel tends greatly to widen the scope of its usefulness.

At the end of 1937, operating companies of the System were serving directly, through more than 30,000 miles of gas pipe lines, 1,102,491 gas customers in 1,491 communities with a total population exceeding 5,000,000. During the year, gas sales amounted to 147,524,469 mcf. Normal business expansion, growth in population, ever widening use of time and labor saving appliances . . factors characteristic of our national progress . . should increase this volume.

COLUMBIA SYSTEM

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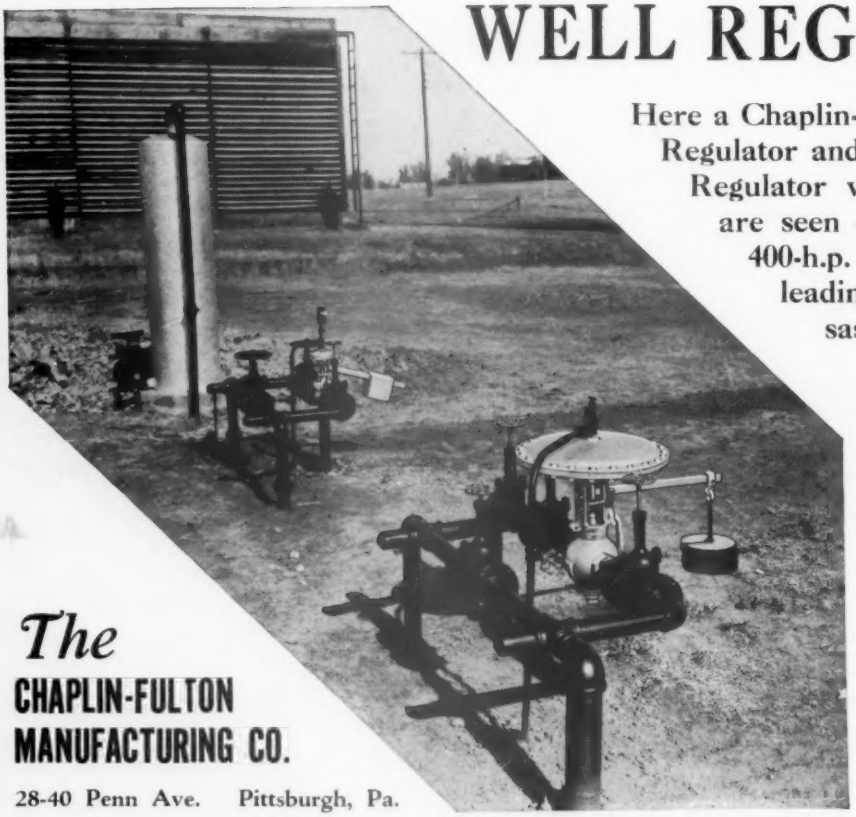

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# Damages Resulting from Turning Off Gas

By
**Leo T. Parker**
Attorney at Law
Cincinnati, Ohio

VARIOUS courts here held that a gas company cannot under any circumstances be held liable in damages for failure to supply gas when the contract with the consumer does not contemplate supplying gas for a particular purpose.

For instance, in Warfield National Gas Company v. Anderson, 61 S. W. 27, a chicken raiser extended the gas pipes to an out-building where he was raising baby chicks for commercial purposes. The gas thus piped to the outbuilding was used in heating the brooders in this brooder house. On October 18, he had on hand 921 six weeks old chickens in his brooder house. On the morning of that day the gas supply failed due to frost getting in the regulator. It was almost two hours before the regulator was defrosted and the gas supply restored. In the meantime, due to lack of heat and condensation, the chicks became wet and chilled. As a result, a great many of them died and the rest were so damaged that when later sold they were disposed of at a loss.

The chicken raiser sued the gas company for damages. Although the lower court held the company liable the higher court reversed the verdict, because the company had contracted to supply gas for domestic and residential purposes but it had not agreed to supply gas to be used in a chicken brooder, saying:

"Here the contract was for domestic and residential purposes. It is conceded that the chicken enterprise of Anderson (chicken owner) was a commercial purpose. As appellant (company) had not contracted to furnish gas for that purpose, it would be unfair to put upon it a liability for damages for failure to keep up a gas supply out of all proportion to such liability where the use was simply domestic or residential."

### Consumer Violates Company Regulation

The law is well established that when a gas company requires consumers to pay for the use of gas by monthly installments in advance, or when the consumers otherwise conform with regulations as to making payments, the company is required to furnish them with gas in proper and sufficient amount to subserve the purpose for which the payments are made. Moreover, the company cannot avoid liability, for the failure to supply sufficient gas, by proving that it has no gas it had, so long furnished all the gas it had, so long as it retained the money received from its patrons in payment for gas and the contract to furnish gas remained in force.

Moreover, a gas company is liable in damages for losses, inconvenience, or sickness caused consumers as a result of turning off gas although the consumer refused to conform with the company's regulations, if the consumer was not obligated to abide by the terms of such regulations. Moreover, although a consumer violates a valid regulation the company cannot without liability cut off the gas supply if the consumer will be severely damaged.

For illustration, in Indiana Natural Gas Company v. Anthony, 58 N. E. 868, it was disclosed that a consumer was being supplied gas through a mixer for use in heating a dwelling. Without consent of the gas company the consumer removed the mixer and was conducting gas into the heater by a large pipe. The gas company employe shut off the gas supply, after the consumer refused to reattach the mixer.

When the gas was shut off, the consumer was not in arrear in payment of rates, but had paid the same in advance. Also, the weather was severely and excessively cold, and the consumer had no other means of warming his house, except a cooking stove which was wholly inadequate. The consumer made immediate demand of the gas company to turn on the gas, and informed the gas company that, on account of the coldness of the weather, himself and family would suffer from the cold. However, the company refused to turn on the gas, and for four days and nights deprived the consumer of gas. He and his family suffered greatly from the cold, and suffered great bodily and mental pain and distress from the cold weather.

The consumer sued the company for damages. During the trial the counsel for the gas company argued that since the consumer had violated a valid company regulation, the company had a legal right to turn off the gas supply. However, it is interesting to know the higher court held the company liable, saying:

"The removal of the mixer was unlawful, and this wrongful act could not be excused because of the company's failure to furnish sufficient gas through the mixer. When consumer removed the mixer without the company's written consent, it had the right to shut off the supply of gas. But this wrongful act on the part of the consumer did not absolve the company from furnishing sufficient gas to consumer, for which it had received pay. Consumer, under the averments of his complaint, was entitled to recover from all immediate injuries and damages resulting from the wrongful acts of company, and such wrongful acts cannot be excused on the ground that consumer was also guilty of a wrong, unless consumer's wrong was the proximate cause of the injury."

### Inconvenience of Consumer

Although a consumer is greatly inconvenienced by the act of a gas company, which cuts off a gas supply, the consumer may not recover damages.

For illustration, in Detroit Gas Company v. Moreton Truck & S. Company, 69 N. W. 659, it was disclosed that a gas company cut off a gas supply from a business plant, when the consumer refused to pay for a gas meter. The consumer sued the gas company for damages. However, after the company had cut off the supply the consumer continued in business using other source of light and heat. Therefore, the higher court refused to allow any damages, saying:

"After the meter was removed, he used lamps and lanterns, which were cheaper than gas. Inconvenience, unaccompanied by pecuniary loss, is not an element of damage upon being deprived of the use of property."

Also, in Wink Gas Company v. Huskey (1931; for example Civ. App.) 42 S. W. (2d) 819, a gas company wrongfully disconnected the gas in a rooming house and restaurant. The high court affirmed that portion of a judgment which awarded damages in the sum of $75 for loss of business, but $25 for damages for inconvenience to the consumer was held to be too speculative, and was disallowed.

### No Damages Proved

Frequently, a gas company employe may enter a building and turn off gas when not knowing that the consumer paid an overdue bill. Under these circumstances the gas company is liable for the trespass *only*, unless the consumer proves other damages.

For example, in Dobbs v. Northern Union Gas Company, 137 N. Y. S. 785, it was shown that an employe of a defendant gas company entered upon and disconnected the gas supply at about 2 P. M. At one o'clock, or one hour previously, the consumer paid at the company's office the unpaid bill. In view of these facts the consumer sued the gas company for heavy damages. However, the court awarded the consumer only $50.00 which was solely based upon the trespass by the employe of the consumer's property. This court said:

"In view of the circumstances, I do not think it can be said to have constituted a mere technical trespass, for which only nominal damages could be recovered."

### Profit Not Proved

It is a well established law that loss of profits is an element of damages for failure of a gas company to fulfill its duty to supply gas, where the profits are not remote and conjectural.

For example, in Shepard v. Milwaukee Gaslight Company (1862) 15 Wis. 318, 82 Am. Dec. 679, without legal cause a gas company refused to supply gas to the owner of a hardware store, thus making it more difficult for him to locate merchandise and rendering the store less attractive to customers than other stores which were lighted with gas.

In holding the gas company liable the court said:

"It seems to me that the profits of an established business are quite as capable of being ascertained with reasonable certainty as the profits to arise from a single contract or adventure. There is, in a case of such business, the experiences of the past to serve as a test. And the rule—that the damages should be estimated 'according to the average percentage of mercantile profits' could readily be applied, and would seem just and reasonable."

Of course, if the business is newly established and the profits cannot with reasonable certainty be calculated, then the court will not allow damages based upon profits.

For instance, in Morey v. Metropolitan Gaslight Company 6 Jones & S. (N. Y.) 185, a boarding-house keeper who also did laundry work had not been long established in her place of business at the time when her supply of gas was shut off, the court held that there could be no recovery for resulting loss of profits, saying:

"She had not long enough conducted the business to make her then profits a test for all the future time she was deprived of the use of gas. She furnished but one instance of the loss of boarders because there was no gas in the house. They may have left for other reasons. She had no fixed and permanent business, continuing for a sufficiently long period, to make it a safe reliance for the future."

### Company Employe Violates Agreement

Of course, if an authorized gas company employe agrees for any reason not to turn off gas, and a gas company employe violates this agreement and turns off the gas, then the company is liable for actual damages sustained by the consumer.

For example, in Birmingham Gas Company v. McKinley, 154 So. 562, it was shown that a consumer was using gas for cooking and also for heating a dwelling. Each account was separate, but the gas company turned off gas for both accounts on the grounds that the account for the gas used for heating was in arrears. The consumer sued the gas company and proved that the company employe had agreed not to turn off the gas until he had time to adjust the account. Therefore, the lower court held the company liable for $3,000 damages. The higher court upheld the general verdict, but reduced the damages to $400.00, saying:

"Plaintiff (consumer) could not be thus led into the continued use of domestic gas in reliance upon defendant's (company's) promise and assurance of an adjustment and time to pay, if anything found due on the other account, and then, without warning, have such agreement revoked and the gas disconnected. A contrary conclusion would run counter to a sense of justice and fair play."

### Estimating Damages

Various courts have held that if a gas company breaches a contract and fails to supply gas for operation of a factory, the damages allowable cannot include anticipated profits but merely include the actual losses sustained by the factory owner as a result of the factory being idle.

For example, in Paola Gas Company v. Paola Glass Company, 44 Poc. 621, it was disclosed that the Paola Glass Company brought suit against the Paolo Gas Company to recover damages for breach of a contract in which the gas company agreed to deliver at the works of the glass company, for 10 months from September 1, all the gas necessary to run a 12-pot glass factory for the manufacture of glass bottles; and it was further agreed that the contract included the use of gas for accessory purposes, together with heating and lighting the glass works. The sum to be paid by the glass company was $300 per month, which was to include only the actual time when gas was furnished; and it was further agreed that the gas company would exercise due care to furnish the natural gas continuously, unavoidable casualties accepted.

The gas company commenced to deliver gas about October 5, but upon commencing the operation of the factory the glass company found that it was unable to melt material properly because of an insufficient supply of heat, which was caused by the failure of the gas company to furnish a sufficient amount of gas.

During the trial testimony was given which proved that the glass company had suffered damages as follows: "The net cost of attempting to operate factory, $9000; also, the loss of profit which would have been made, $10,000."

The lower court held the gas company liable in $19,000.00 damages, but the higher court reversed this verdict stating important law as follows:

"The contract having been broken by the gas company, it must be held liable for all the direct and proximate damages."

*(Concluded on page 51)*

# Naphthalene Removal

By
**C. J. Smith**
Superintendent, Gas Dept.
South Carolina Power Co.

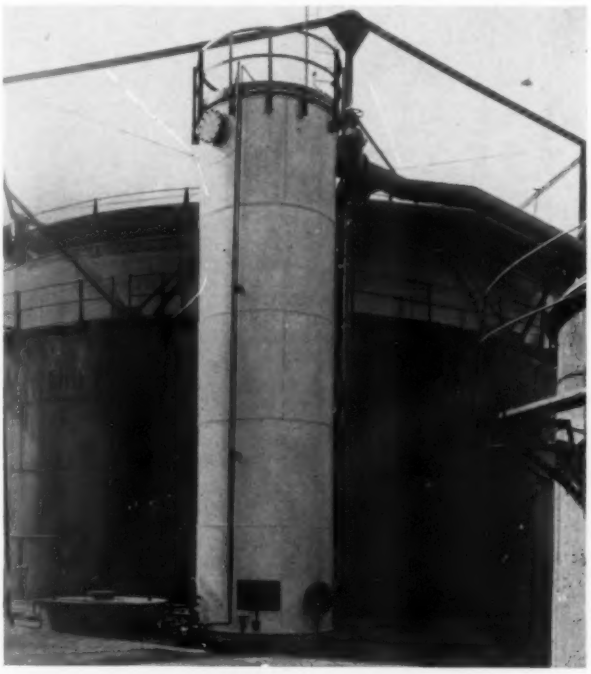
THE removal of naphthalene from manufactured gas by absorbtion with oil in an absorbing tower is well known to the gas industry and needs no detailed description. However, the application of this process in a southern seaboard town such as Charleston has characteristics of sufficient interest to warrant description. It was not found necessary to wait for years to clean out the distribution system before obtaining full benefit from naphthalene removal.

The chemical compound, naphthalene, formed by the combination of 10 atoms of carbon with 8 atoms of hydrogen, is a white, solid, flaky substance at ordinary temperature. It may be formed in the manufacturing process when certain hydrocarbon gases are subjected to high heat and undergo chemical change. Every experienced operator knows that it has properties which make it a very undesirable constituent of manufactured gas.

The naphthalene is carried in the gas as a vapor at high temperatures and sublimes from a vapor to a solid with lowering temperatures. This property of naphthalene to change its physical state readily with changing temperatures makes it a wanderer in the gas distribution system because it may be present as a solid where a low temperature prevails and then change to a vapor as it becomes warmer, only to be deposited again as a solid where the gas becomes cooler. Much to the gas man's sorrow, this usually happens at some very important part of the distribution system, and brings about very definite service problems and customer complaints.

Since the earliest days naphthalene has been a great source of trouble in many manufactured gas distribution systems where no effective means of naphthalene removal has been in use. The advent of heavy oil, with its necessarily high carburetting temperatures, together with the use of high percentages of bituminous coal in modern water gas production has tended to increase the amount of naphthalene in gas and added to the distribution problems resulting from naphthalene stoppages.

This condition has been experienced at the Charleston gas plant of the South Carolina Power Company, and the naphthalene stoppages are especially aggravated by a chain of circumstances peculiar to this city. The gas services are laid at a relatively shallow depth on account of the low ground level in the city and its proximity to salt water. The majority of the service risers, gas meters and fuel lines are exposed to the atmosphere because of the almost complete absence of cellars in the dwellings. The temperature of the gas, therefore, is quite susceptible to changes in atmospheric temperature; and numerous naphthalene stoppages in services, meters and fuel lines resulted during the season of the year when the atmosphere was considerably cooler than the ground and plant cooling water temperatures. Naphthalene is very readily affected by changing atmospheric conditions due to its relatively high vapor pressure. The vapor pressure approximately doubles with every rise in temperature of ten degrees Fahrenheit. As the warm summer season closes and the atmospheric temperature lowers before the plant cooling water and the ground temperatures have proportionately lowered, it is possible that the gas will be cooled as much as thirty degrees Fabrenheit in service risers, meters and fuel lines. The gas, saturated with naphthalene at the higher temperature, will deposit as much as 30 grains of naphthalene per 100 cubic feet with the above reduction in temperature. This solid, flaky naphthalene is deposited in all parts of the house piping, exposed services, meters and other regulating devices. These deposits may be of considerable thickness and volume. Stoppages can become so serious that sections of main will be cut off, thereby putting a great number of customers out of service at one time and costing considerable sums in rectifying the complaints.



Napthalene Absorbing Tower

The effect of a few days of cooler weather on naphthalene complaints may be seen from the following tabulation.

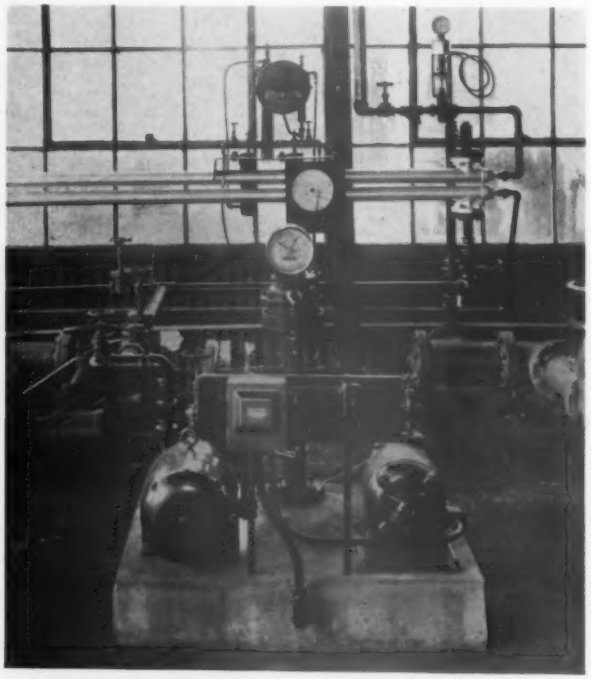
| 1935 | Average Atmospheric Temperature | Number Naphthalene Stoppages |
|---|---|---|
| Oct. 5..... | 71 | 12 |
| 6..... | 62 | 26 |
| 7..... | 54 | 52 |
| 8..... | 60 | 49 |
| 9..... | 64 | 53 |
| 10..... | 70 | 16 |

The gas temperature in the mains being high enough to maintain about 30 grains per 100 cubic feet in the vapor state is immediately lowered in the services, meters and fuel lines which are exposed and the naphthalene is crystallized out of the gas, accumulating at these points and causing stoppages.

The best method of overcoming naphthalene troubles is to remove the naphthalene from the gas before it leaves the plant. With the use of bunker oil for carburetting and high percentages of coal in the generator the difficulties at Charleston increased to a point where the management decided to install suitable apparatus to remove the naphthalene from the gas before it left the plant. Accordingly, a contract was awarded to the Koppers Company, Western Gas Division, to install Koppers Company patented naphthalene removal apparatus. The process consists of washing the gas with absorbing oil in a gas absorbing tower. The operation takes place in two steps. The gas is first scrubbed in a recirculating section of the absorber where part of the naphthalene is removed by oil which is constantly recirculated through this section. The gas then enters the second section where periodic small amounts of fresh oil are added and the remainder of the naphthalene in the gas is removed.

The absorber at Charleston is built in three parts, a primary, secondary and dehydration section. The dehydration division is not used at present, but was put in to facilitate possible future dehydration of the gas. It was possible to provide three sections at little additional expense because there was available a washer cooler which was out of service. It was redesigned as the gas absorber and was of sufficient size to provide three sections.

The absorber is constructed so that the gas passes upward through each division. The sections are packed with wooden trays arranged in such a manner as to give intimate contact between the absorbing oil and the gas. In the primary section oil is constantly recirculated thru sprays at the top and passes downward over the trays countercurrent to the gas flow. The oil in this step of the process becomes saturated with naphthalene, the concentration depending on the temperature of the gas. The partially stripped gas then passes upward thru the secondary section, where small amounts of fresh oil are periodically added through sprays at the top and this fresh oil absorbs the remainder of the naphthalene from the gas. As the fresh oil reaches the bottom of the absorber it mixes with the recirculating oil and freshens it to a certain extent. The spent oil overflows from the bottom to an underground tank from which it is pumped to the gas oil storage tank and used for gas making.



Pumps, Meters and Heater For Naphthalene Removal

Two pumps are used: A small centrifugal pump to recirculate oil in the primary section, and a positive displacement pump to move oil from the fresh oil storage tank to the secondary section. A finned tube heater is used to heat the recirculating oil. The steam to this heater is controlled by a direct acting temperature controller and the temperature of the oil is kept a few degrees above the gas temperature in order to prevent any condensation of water from the gas. A regular indicating flow meter is provided to measure the amount of recirculating oil in gallons per hour while a small positive oil meter is used to measure the fresh oil.

The construction work incident to the installation of this apparatus was completed in the summer of 1937 and the process was immediately put in operation. The plant cooling water is taken from the harbor, and in summer it attains a temperature as high as 85 degrees Fahrenheit. This limits the extent to which the gas can be cooled to about 90 degrees Fahrenheit. Because of the high vapor pressure of naphthalene it is necessary to use about 60 gallons of fresh oil per million cubic feet of gas in the naphthalene absorber at this high temperature. The amount of fresh oil is so regulated as to effect about 90% removal of the naphthalene in the gas. The removal of this amount is enough to insure that no crystallization will take place anywhere in the distribution system even though the gas temperature be lowered as much as 40 degrees. In addition, the gas, being relatively free of naphthalene, will absorb deposits from the distribution system until the amount of naphthalene in the gas reaches an equilibrium at the prevailing temperature of the gas in the mains. In this way it is possible to clean up old deposits throughout the distribution system. When the mains become free of naphthalene deposits and the gas is satisfactorily purified before leaving the plant there is no possibility of further stoppages.

When napthalene purification apparatus is put in operation in a gas plant it is usually from one to three years before complete freedom from service stoppages is obtained. After the gas is sufficiently purified it takes that length of time for the deposits

in holders, mains and meters to be taken up by the clean gas. Such a condition prevails in plants where the cooling water and ground temperatures vary only within a narrow range during different periods of the year. This situation is general more in the northern section of the country than in some parts of the south, especially along the seaboard where there is usually a substantial periodic change in the difference between cooling water and ground temperatures.

The principal difference between the experience at Charleston and that at other places where naphthalene purification has been installed has been a complete absence of naphthalene stoppages from the day when the process was started. The apparatus was put in operation in the summer of 1937, and the cooler fall season came on with no stoppages due to naphthalene deposition. This was in direct contrast to the same periods of previous years when more than 200 complaints were sometimes recorded in one week.

This may be explained as follows: The temperature of the gas leaving the plant during the summer months is as high as 95 degrees Fahrenheit, and enough fresh oil was used in the naphthalene removal process so that practically all the naphthalene was removed from the gas, even at this high temperature. This clean gas, in traveling through the distribution system at a high temperature, absorbed all the naphthalene from the mains and carried it away before the atmosphere cooled sufficiently to throw down the naphthalene again at some other location. During this time the gas entering the naphthalene absorber at the plant contained about 30 grains per 100 cubic feet, and this was removed in the absorption process. The clean gas then entered the mains and was distributed at a temperature of about 85 degrees.

The vapor pressure of naphthalene is high enough to saturate the gas to the extent of about 35 grains per 100 cubic feet at this temperature and in so doing all the old naphthalene deposits were cleared up before cooler atmospheric conditions were encountered.

The cost of operation for the process is very low. The oil used in the absorber can be mixed with the regular gas oil and use in water gas manufacture. In fact, the volume of oil increases somewhat during the process due to the condensable light oils which are taken up from the gas by the absorbing oil. The heat content of the gas is not materially decreased because the absorbed light oils would otherwise be lost through condensation. A slight credit is therefore reflected back to naphthalene removal because of the increase in volume of absorbing oil. The only other direct operating cost is current for the small motor driven pumps for pumping oil. The steam for heating the oil in winter is waste exhaust steam. No additional labor is required. In fact very little attention is necessary as the process is practically self operating.

## Damages—Turning Off Gas

*(Continued from page 48)*

Therefore, to summarize, the general law appears to be well established that a gas company is not liable for turning off gas, or failure to supply gas, if the gas company had not contracted to supply gas for the particular purpose for which the consumer intended to use it. Also, the gas company is not liable for mere inconvenience suffered by a consumer although the gas supply is illegally cut off. And, if the consumer fails to prove that he was actually damaged, then the company is not liable under any circumstances.

On the other hand, the gas company is liable in damages for its failure to supply gas, or for illegally cutting off the gas supply, if the consumer actually suffered damages and the gas company was legally obligated to supply gas. In other words, the gas company is liable for all the direct and proximate damage resulting to the consumer if failure to supply gas is a legal breach of a valid contract between the company and the consumer.

## Lincoln Electric President Announces Establishment of Manufacturing Subsidiary in Australia

Mr. J. F. Lincoln, President, The Lincoln Electric Company, Cleveland, Ohio, announces establishment of a manufacturing subsidiary to be called Lincoln Electric Company (Australia) Pty., Ltd., at Sydney, Australia. A suitable factory has already been purchased and arc welding equipment manufacturing operations will begin in a year's time.

Commenting on the establishment of the Australian plant, Mr. Lincoln expresses great faith in Australia's industrial future.

"Here is a land of opportunity," said Mr. Lincoln, "a country of small population, unlimited natural resources, with a people entirely imbued with the pioneer spirit and the wish to share their country with other pioneers of the white race who wish to come in.

"It is unfortunate that in the United States so little is known about this great continent. We perhaps know of it as the place where rabbits are a nuisance, kangaroos are indigenous, a Labor Government has caused much trouble and the workman is entirely Unionized. All these things are true, but they are of little importance in its future development, all dangerous things are now under control.

"Australia has tremendous areas of the finest farming land now available, has untouched natural resources of enormous wealth and has the greatest opportunity for the young man of initiative, physical, mental and spiritual strength that can be found anywhere. All that he needs is ambition, the desire to work and the determination to help a country develop.

"The man of wealth also, has a great opportunity in investment here. There is no unfair legislation to inhibit the man of initiative who not only wishes to put in his work but also his capital.

"Development of an industry here is not a crime but is held to be a virtue. Profit from work and initiative is held in esteem. Progress is desired."

While in Australia, Mr. Lincoln visited all the capital cities, giving a series of addresses before various engineering societies and groups on developments in the art of welding. Great interest in welding was indicated by the large enthusiastic attendance wherever he spoke. He is expected back in the United States in May.

**J. F. Lincoln, President, The Lincoln Electric Company, in Australia, where he believes, there is a great industrial future and that his business there, like his friends in the picture, will progress by leaps and bounds.**

# The Flow of Fluid Through Pipes

## Part I

by

**Allen D. MacLean,**

Chief Engineer
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ONE of the most obviously important phases of the study of fluid flow through piping is that relation which exists between pipe size, length of line, pressure loss, and rate of fluid flow. This relation must be used in selecting the pipe size necessary to transport a given volume of fluid. Even the most elementary and preliminary consideration of any fluid flow problem will necessarily employ it in one form or another. Naturally, then, many engineers and scientists have studied this particular problem, and we find an extensive bibliography on the subject.

The theoretical and mathematical work on the flow of fluids through piping systems attracted many important scientists to the problem just about the time closed piping came into extensive use. Bernoulli, in the latter part of the eighteenth century, and Wantzel and Navier, in the first part of the nineteenth century, quite thoroughly covered the subject from the mathematical and theoretical aspect. Their formulae are really the basis for the present day mathematical relations which are applied practically. Poiseuille's work on viscous flow was a valuable contribution to the theoretical aspect of the problem, and the deduction of Reynolds on certain relations between the physical factors involved provided an important forward step, permitting a rational correlation of the work of many independent experimenters.

As is true with most technical work, it was found that the carefully devised mathematical formulae on fluid flow required considerable actual experimental data before they could be useful in solving practical problems. The list of investigators who provided experimental data on this subject include Zeuner, Fliegener, Napier, Rateau, Blasius, Stanton and Pannell, Hazen and Williams, Weymouth, Prandtl, and various governmental and educational agencies.

The theoretical approach to the problems of fluid flow was first made by Bernoulli, who considered the problem in the light of the kinetic energy possessed by the flowing fluid at two different points along its course of flow. The fundamental approach, however, is made from a study of the total energy, of all kinds, possessed by the fluid at two separate points along the piping system. This type of analysis is fundamental, and besides forming the basis for simple fluid flow formulae, will be useful in studying rate of flow meters, such as the venturi and the orifice meter.

Nearly all of the flow formulae found in practice take the same general form, and result from the same mathematical reasoning which Bernoulli originally used. The following derivation is typical of the physical and mathematical steps taken to arrive at a general equation.

From a consideration of continuity, providing there is no addition or loss of energy through the piping system, the total energy possessed by a unit mass of the flowing fluid along its course of flow is the same at all points. In Figure 1, at point I, if the velocity is expressed by $S_1$, the kinetic energy which a unit mass possesses is $\frac{S_1^2}{2g}$, with g being gravitational acceleration. The intrinsic energy at the point I, i.e., the energy made up of heat energy possessed by a unit mass, and pressure on a unit mass, can be expressed by $U_1$. Then the total energy is $U_1 + \frac{S_1^2}{2g}$. Similarly at II, the total energy is $U_2 + \frac{S_2^2}{2g}$.

If there is any change between the total energy possessed by a unit weight at I, and that possessed at II, it can occur in but two ways; first, by adding or subtracting heat energy (which we will call q) from the fluid through the walls of the pipe system; or, second, by doing work on the fluid, or making the fluid do work between the two points. In this last consideration is included the work done in overcoming friction, both internal and at the pipe surface, in flowing between I and II.

A unit mass of the fluid entering at I has work done on it, and the unit of mass leaving at II does work on the unit just preceding it. The work done at I can be determined by letting $p_1$ equal the pressure at I in pounds per square foot, and $v_1$ the specific volume, in cubic feet per pound. The actual force existing at I is $p_1A_1$, where $A_1$ is the area of the pipe section at I. The actual distance which one pound of the fluid occupies along the pipe line is $\frac{v_1}{A_1}$, and this must represent the distance through which force $p_1A_1$ moves this pound. Hence the work done, being the product of the force times the distance, is $p_1A_1 \times \frac{v_1}{A_1} = p_1v_1$. Similarly the work done at section II $= p_2v_2$.

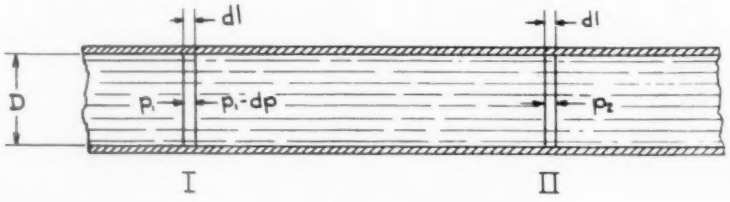


Figure 1

The difference between the total energy at I and at II is equal to the work done on or by the fluid in passing from I to II. This can be expressed mathematically by the equation:

$$\left(U_1 + \frac{S_1^2}{2g}\right) - \left(U_2 + \frac{S_2^2}{2g}\right) = q + (p_1v_1 - p_2v_2)$$

This equation is the broadest form of the fluid flow relation.

In the above derivation, the work done on, or done by the fluid in passing from I to II is important. In normal flow there is obviously work done in overcoming the friction between the pipe and the fluid, and also, as we will later see, under almost all conditions of flow, internal friction due to turbulence must be overcome. This last factor—turbulence—is one which, due to its great variations and uncertainty, defies logical mathematical analysis, and we must resort to laboratory tests and experiments to evaluate it. However, the problem has been investigated by a great many experimenters, and as we will see later, their work can be coordinated in such a way that we have a very good knowledge of the value of the friction coefficient.

In Fig. 1, at I, the force tending to force the lamina of length $dl$ downstream is $p_1A_1$, the force resisting this is $(p_1—dp)\ A_1$, where dp is the change in pressure in flowing the distance $dl$.

The work done in moving the lamina a distance $dl$ is the force times the distance and is equal to $A_1\ dp\ dl$, and is used in overcoming the frictional resistance f, and in changing the kinetic energy of the fluid.

Because, as is pointed out above the friction factor f is caused by two more or less independent sources, (the friction between fluid and pipe wall, and the friction between layers or sections of the fluid itself in its usually disturbed or tubulent flow) the interdependence of this factor f, and the three factors velocity, area of rubbing surface, and density must be determined from observation of experimental data. It is almost obvious that f will vary directly as the area of the wall which contains the liquid, which is equal to $\pi D \times dl$; it is also a fairly reasonable supposition that f will vary as $\rho$, the fluid density. The relation between velocity of the fluid and the friction factor does not lend itself to such an axiomatic reasoning, and at this point most investigators turn to the experimental data, and note that the factor f seems to vary with the kinetic energy, i.e. $\frac{S^2}{2g}$. The actual explanation of this apparent relation is that the friction factor depends not only on the velocity itself, but also on the viscosity losses in the turbulence of the flow, which also depends on the velocity. Thus the second power of velocity must enter into this friction factor relation. From this consideration, borne out by observation and experimental data, we can say that the friction force varies as the area of the exposed pipe surface, the density, and the square of the velocity. Expressed mathematically

$$dF = f \times \frac{1}{\rho} \times s^2 \times \pi D\ dl \qquad (1)$$

where

$dF$ = the frictional force
$f$ = friction factor
$s$ = velocity
$D$ = diameter of pipe
$dl$ = length of lamina along pipe.

The work done in changing the kinetic energy in passing the distance of the lamina is equal to the mass of the lamina times the square of the change in velocity. The mass of the lamina is $A\ dl\ \rho$, and the change in velocity is ds. The change in kinetic energy can then be written

$$A\ \rho\ dl\ ds^2 = A\ \rho\ dl\ 2sds \qquad (2)$$

Remembering that the work done is the change in kinetic energy plus the work done in overcoming frictional effects, we have

$$A\ dp\ dl = 2As\ \rho\ dl\ ds + f\ s^2\ \rho\ \pi D\ dl\ dl \qquad (3)$$

which results in

$$dp = 2s\rho\ ds + \frac{f\ s^2}{A}\ \rho\ \pi D\ dl$$

Substituting for A its equivalent $\frac{\pi D^2}{4}$, we can write

$$dp = 2s\rho\ ds + \frac{4\ fs^2\ \rho}{D}\ dl. \qquad (4)$$

The first term on the right hand side of the equation $2s\rho\ ds$ represents the change in kinetic energy between initial and terminal points, and where we have uniform pipe size and a density which does not change greatly, this change of kinetic energy is very small when compared to the second term of the equation, and can therefore be neglected. Hence for normal pipe line flow work we can write

$$dp = \frac{4\ fs^2\ \rho}{D}\ dl. \qquad (5)$$

Integrating this equation

$$\int_{p_1}^{p_2} dp = \int_{o}^{l} \frac{4\ f\rho\ s^2}{D}\ dl \qquad (6)$$

$$p_1 - p_2 = \frac{4\ f\rho\ s^2\ l}{D} \qquad (7)$$

In this equation the friction factor f must of course be experimentally determined and is subject to careful experimental analysis.

Mainly because most individual experimenters were concerned with but one rather limited range of fluid flow in their investigations, and worked out empirical formulae based on their own experimental data, there are a great number of flow formulae in use. These vary, not only in constants used but sometimes in the mathematical form of the expression. We find certain experimenters working with water flow to determine formulae for the flow of water in normal city systems; others with low pressure manufactured gas; others with steam; still others with natural gas at high pressures. Each wished to solve a rather limited problem and produce practical and workable results for a very definite field of application. In almost every case, therefore, the formula produced could be applied only to a rather limited range of flows, and within relatively narrow limits of pressure loss and pipe size. In a great many cases, the theoretical consideration of fluid flow (such as used in deriving equation 7) was ignored and replaced by purely empirical formulae worked out to fit the limited range of the particular investigation. This accounts for the occasional variation in mathematical form from the fundamental.

As early as 1883, Osborne Reynolds recognized a relation between the physical characteristics of a fluid and its behavior while flowing through a pipe, which permits a very broad application of the fundamental pipe line formulae, not at all limited to any particular field of application. From his work there has resulted a factor known as the Reynolds' Criterion or Reynolds' Number, which permits a rational and logical comparison of all fluid flow data, whether derived with liquid or with gases, independent of the nature of the fluid, and for any pipe size and for any range of velocities. By using this Reynolds Number we

can correlate all available data independent of source (providing, of course, the source is reliable) and derive a value for the frictional factor f in the general formula. This general formula with the friction factor determined on the basis of the Reynolds Number, will give reliable results in all friction factor calculations. In using the general formula in this way, it is not necessary to know the limitations which are imposed on the other types of formulae by the range of data used in the derivation.

The Reynolds Number is one of the interesting phenomena in fluid flow, finding wide application in head meter measurement problems as well as in pipe line flow formulae. One of Reynolds' early observations was that on occasions flow, when observed in a glass tube, appeared to be sinuous and even, without undue turbulence. With certain changes in tube diameter, or velocity of flow, or density of fluid flowing, this flow changed from smooth sinuous flow to turbulent flow, in which there appeared numerous cross currents and eddying flows, as well as the progressing flow along the pipe axis. It was almost self evident that the friction factor under conditions of turbulent eddying flow would be larger than when the flow was smooth and sinuous. Reynolds felt that the velocity, pipe diameter, density, and viscosity of the fluid, all affected the friction factor, and set about to determine their relation. The first steps he made were based on dimensional analysis, and from the Bernoulli theorum he determined by dimensional analysis that the friction factor f has no dimensions.

We can follow the same steps by going back to equation (7)

$$p_1 - p_2 = \frac{4 f \rho s^2 l}{D}$$

and by substituting for each factor its dimensions in the foot-pound-second system determine the dimensional value of f. It will be remembered in the foot-pound-second system of units all physical values are reduced to the three fundamental units of length, (L), mass (M), and time (t), and in any true equation these units must balance.

In formula (7)

p = pressure whose dimensional units are $\frac{M^*}{Lt^2}$

$\rho$ = density whose dimensional units are $\frac{M}{L^3}$

s = velocity whose dimensional units are $\frac{L}{t}$

$l$ = distance whose dimensional units are L

D = diameter whose dimensional units are L

Substituting these dimensions in the equation we obtain

$$\frac{M}{Lt^2} = f \times \frac{M}{L^3} \times \frac{L^2}{t^2} \times L \times \frac{1}{L}$$

It will be noted that all of the dimensional factors on both sides of the equation cancel out which indicates that f must be a dimensionless factor.

Reynolds, in his analysis of the relation of velocity, density, pipe diameter, and viscosity made use of this fact, when he realized that since these four factors made up the friction factor, they must arrange themselves in such a way as to produce a dimensionless value.

If s = velocity, whose dimensional units are $\frac{L}{t}$

$\rho$ = density, whose dimensional units are $\frac{M}{L^3}$

$\mu$ = viscosity, whose dimensional units are $\frac{M}{Lt}$

D = diameter, whose dimensional units are L

the only grouping of these units which will cancel out and give a dimensionless value of f is f =

$$\frac{\rho s D}{\mu} = \frac{\frac{M}{L^3} \frac{L}{t} L}{\frac{M}{Lt}} = 1$$

This grouping of units $\frac{\rho s D}{\mu}$ is known as the Reynolds number, and, as has been stated above, is very useful in fluid flow work.

Reynolds found that the main significance of this simple relation f = $\phi \frac{\rho s D}{\mu}$ is that no matter what the numerical value of each of the four individual variables $\rho$, s, D, and $\mu$, if the numerical value obtained when they are combined in the form $\frac{\rho s D}{\mu}$ is the same, the friction factor f is exactly the same. From this simple relation it is possible to correlate all work done on fluid flow, and by plotting the calculated values of f against the Reynolds Number obtain an extremely useful curve to be used in flow problems, no matter what velocity range is used or what pipe diameter, or what fluid is encountered. In Fig. 2 is shown just such a curve, derived from the work of Stanton and Pannell using both liquid and gas, covering a large range of Reynolds Numbers.

Of immediate interest on examining this curve is the apparent complete change in shape at the Reynolds Number value of approximately 2000. For Reynolds Numbers below this value, the curve has a very sharp slope (plotted on logarithmic abscissae).

At a Reynolds' Number value of about 2000, there can be observed the start of a region in which the Reynolds' number increases rapidly, though in a rather spotty or uncertain manner. At a value of 3000 the number has increased considerably and from 3000 on, it is again a definite curve and decreases gradually with increasing Reynolds' Number. At the region of sharp increase, we assume (correctly) the change from viscous or sinuous to turbulent flow. With small pipes (down to capillary tubes), with low velocities, low densities, and high viscosities, the fluid flows in a man-

**Pressure is usually expressed as the force per unit area, and while it is usual to speak of force in terms of pounds, which is also one unit of weight (and thus related to mass M), the true definition of force in physics must be derived from the acceleration $\frac{L}{t^2}$ which a force F gives a body of mass M. The true unit of force according to the physicist is the poundal; in the expression for force is F = Ma, where a = acceleration in feet per second per second. The dimensions of the force unit, the poundal, then are derived from the equation*

$$F = M \times \frac{L}{t^2} = \frac{ML}{t^2}$$

$$Pressure = \frac{F}{A} = \frac{ML}{t^2} \times \frac{1}{L^2} = \frac{M}{Lt^2}$$

*and these dimensions for pressure must be used in any dimensional analysis such as that given above.*

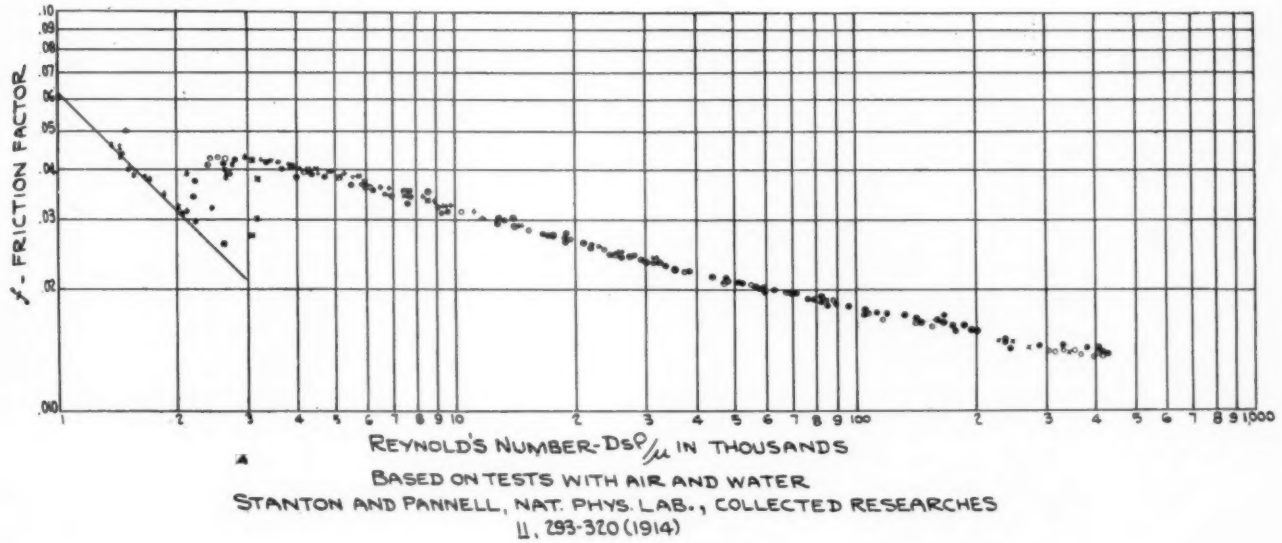
f - FRICTION FACTOR
REYNOLD'S NUMBER - Dsρ/μ IN THOUSANDS
BASED ON TESTS WITH AIR AND WATER
STANTON AND PANNELL, NAT. PHYS. LAB., COLLECTED RESEARCHES
11, 293-320 (1914)

Figure 2

ner we call viscous. Each radial lamina sheers over its neighboring lamina, without causing any serious deviation from true parallel flow, parallel to the pipe axis. At the pipe surface, there may be a small amount of turbulence due to friction between the pipe surface and the fluid, but the flow in the remainder of the section is smooth and sinuous. Each section does not necessarily have the same velocity; in fact the velocity will increase somewhat as measured in lamina going from the pipe walls toward the center of the pipe.

Under those conditions, where the four variables comprising the Reynolds Number combine in the expression $\frac{\rho s D}{\mu}$ to give values above 2000 the flow becomes "turbulent." Beside the forward component of velocity along the pipe line, there are also components which are at an angle to it. Eddying and swirling appear, in addition to forward movement. This of course results in a larger friction factor, which accounts for the jump in the curve just at the transition point from viscous to turbulent flow.

As yet in our discussion of friction in fluid flow we have said but little of the actual "skin friction" between the fluid and the pipe. In practical work, almost all flow is in the turbulent range, where a large portion of the energy loss is in turbulences, rather than in actual pipe contact friction. However, we do know that pipe roughness is a factor which must be taken into our calculations. In reality we must then add a fifth variable to those affecting our general term friction factor; to velocity, viscosity, pipe diameter, and density, we must add surface condition of the pipe.

Research and mathematical investigations were made by Pigott and Kemler, in which calculated friction factors were grouped by pipe size and pipe condition. It was found that a family of curves in reality must be used to express the relation of friction factor to Reynolds Number. Actually this family is a fanwise group, having nearly the same f value at low Reynolds Numbers, but spreading as the Reynolds Number increases. Fig. 3 is a representation of this family of curves based on the above-mentioned work. With completely smooth pipe, which drawn brass tubing would approach, on the very large pipes 36" and above, we find a friction factor which decreases rather sharply with increasing Reynolds Number. At the other end of the scale completely rough pipes, and very small ones have a practically constant friction factor. The table given with the curve in Fig. 4 sum-

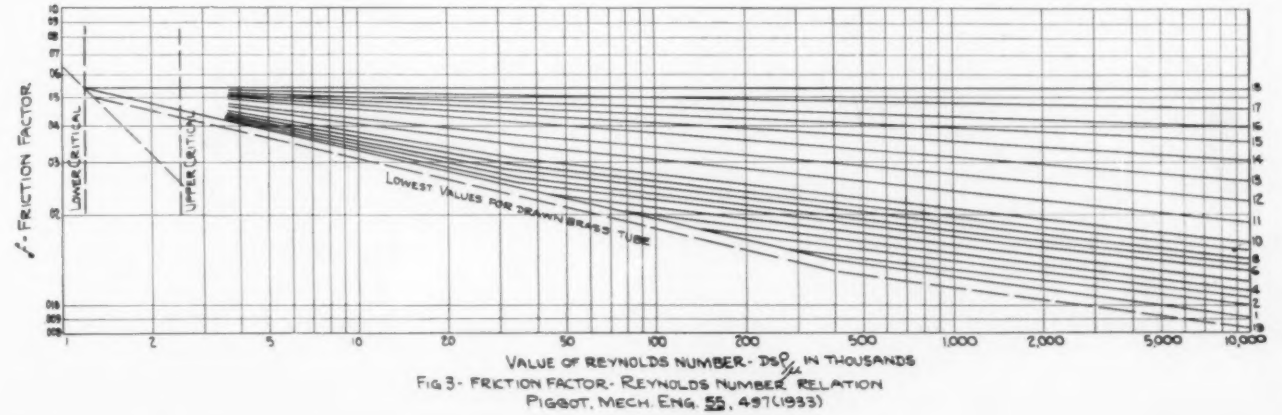
f - FRICTION FACTOR
LOWER CRITICAL
UPPER CRITICAL
LOWEST VALUES FOR DRAWN BRASS TUBE
VALUE OF REYNOLDS NUMBER - Dsρ/μ IN THOUSANDS

FIG 3 - FRICTION FACTOR - REYNOLDS NUMBER RELATION
PIGOT, MECH. ENG. 55, 497 (1933)

Figure 3

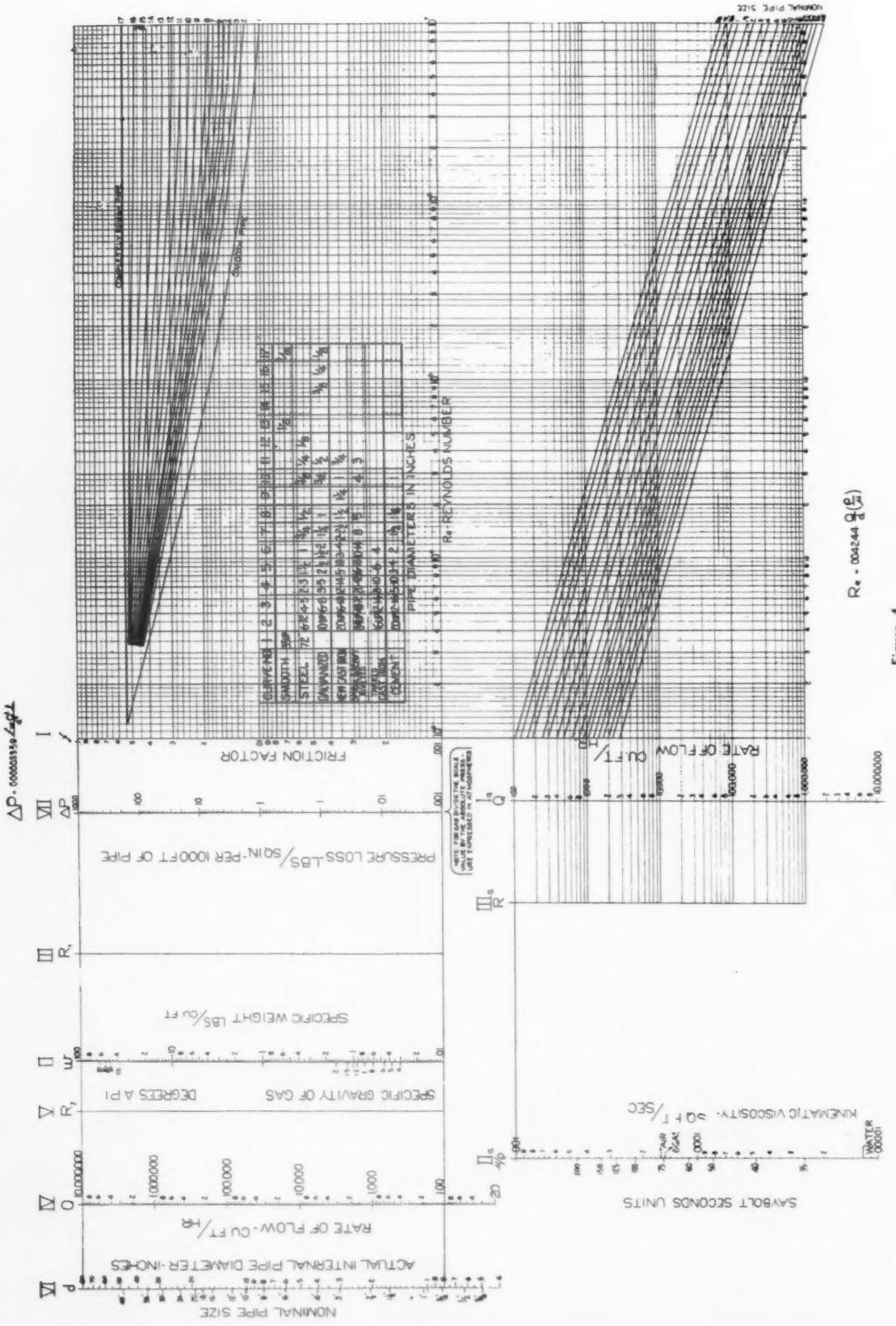
FRICTION FACTOR
PIPE DIAMETERS IN INCHES
Re REYNOLDS NUMBER
Re = .004244 q (G/d μ)
RATE OF FLOW CU.FT./HR
PRESSURE LOSS-LBS/SQ.IN.-PER 1000 FT OF PIPE
SPECIFIC WEIGHT LBS/CU FT
SPECIFIC GRAVITY OF GAS
DEGREES A.P.I.
RATE OF FLOW - CU FT/HR
ACTUAL INTERNAL PIPE DIAMETER-INCHES
NOMINAL PIPE SIZE
KINEMATIC VISCOSITY - SQ FT/SEC
SAYBOLT SECONDS UNITS
AIR
GAS
WATER

Figure 4

marizes the data on which the curve is based, and each particular problem should be studied with respect to this table in determining the value of f to use in the formula.

In the usual practical application of any fluid flow formula, the arrangement of the variables as in equation 7 is not the most adaptable one. The factor s is not usually known and must be computed from the expected rate of flow in units of volume per second. Also since pipe diameter may be an unknown member of the equation, and has its influence on velocity, the determination of the Reynolds Number presupposes a number of "cut and try" calculations. To make this step easier, and to visualize the friction factor-Reynolds Number relation so that it can be properly applied in the fluid flow computation, the graph shown in Fig. 4 has been prepared.

The Reynolds Number, we have seen, can be expressed by the equation

$$R_e = \frac{\rho s D}{\mu}$$

However, in actual practice, the velocity of flow as such is seldom known or required. Rate of flow in volume units per unit of time is a quantity which is of practical use and can be substituted.

Let $Q'$ = rate of flow in cubic feet per second

Then $Q' = \frac{s \pi D^2}{4}$

where

s = velocity in feet per second

D = diameter of pipe in feet.

$$s = \frac{4 Q'}{\pi D^2}$$

$$R_e = \frac{4 Q'}{\pi D^2} \times D \times \frac{\rho}{\mu} = \frac{4}{\pi} \times \frac{Q'}{D} \times \frac{\rho}{\mu} \qquad (8)$$

In equation 8, the value $Q'$ is expressed in cubic feet per second, whereas rate of flow in cubic feet per hour, Q, would be a more convenient value. By using the relation $Q = 3600\ Q'$ our expression can be changed. Similarly, pipe diameter in feet D is cumbersome, so we can replace by pipe diameter in inches d, by using the relation $D = \frac{d}{12}$. Equation 8 then becomes

$$\text{Reynolds Number} = \frac{4}{\pi} \times \frac{Q}{3600} \times \frac{1}{\frac{d}{12}} \times \frac{\rho}{\mu} = .004244 \frac{Q}{d} \times \frac{\rho}{\mu} \qquad (9)$$

The expression $\frac{\rho}{\mu}$ is in effect the reciprocal of the kinematic viscosity $\frac{\mu}{\rho}$. The kinematic viscosity for the fluid being handled must be known; it is usually, for liquids, determined by means of a viscosimeter and the Saybolt viscosimeter is used very generally in making viscosity determinations. In principle the Saybolt viscosimeter is a very carefully made capillary tube, through which the fluid flows by gravity. The time, expressed in number of seconds for 60 cubic centimeters of fluid to pass through this capillary is noted and this number is called Saybolt viscosity expressed in Saybolt Second units. Since the flow is produced by gravity, the density of the fluid influences the time of flow to as great an extent as does the viscosity, hence the value as given by the Saybolt viscosimeter is in reality $\frac{\mu}{\rho}$, or the kinematic viscosity. On examining equation (9) it will be seen that the factor $\frac{\rho}{\mu}$, the reciprocal of the kinematic viscosity can be used directly in the Reynolds number determination. Thus to obtain the Reynolds number it is necessary to multiply the rate of flow in cubic feet per hour by the diameter of the pipe in inches, divide by the kinematic viscosity in feet squared per second, and multiply by the constant .004244.

To facilitate work with the Reynolds Number, in Table 1 is listed the kinematic viscosity $\frac{\mu}{\rho}$ of various fluids. Column II of this table lists the reciprocal value $\frac{\mu}{\rho}$, which can be substituted directly in equation (9).

Referring to the chart in Figure 4 it will be seen that the lower half is devoted to the determination of the Reynolds number. At the lower left side a scale labeled IIa is provided for the kinematic viscosity. To facilitate use, the more common fluids such as air, water, gas of .6 gravity are prelocated on this scale. Scale Ia gives the rate of flow expressed in cubic feet per hour. By connecting the correct point on Scale Ia with Scale IIa an intersection is obtained with reference scale, IIIa. The value on reference scale IIIa can be projected horizontally to the right where it will intersect a series of diagonal lines, each representing a pipe size. The numerical value on the horizontal scale marked $R_e$ — Reynolds Number of the vertical projection of this intersection point for any size pipe gives the value of the Reynolds number for the conditions of flow, i. e. given fluid, given rate of flow and selected pipe size.

In using scales Ia and IIa for gases, it should be noted that if Q is expressed, as is usually the case in gas work, in equivalent cubic feet at atmospheric pressure, instead of cubic feet at the pressure at which it is flowing, then the value for kinematic viscosity is taken as that at atmospheric pressure, and appears on scale IIa prelocated for air and some of the normal gases. If Q is expressed in actual volume of gas at flowing pressure, then the kinematic viscosity at flowing pressure must be used.

The upper right hand section of Figure 4 is used to give the relation between the Reynolds number and the friction factor f to be used. Unfortunately, the friction factor, in addition to depending on the Reynolds number, depends somewhat on the nature of the interior surface of the pipe, and the relation of this interior surface to the diameter. This fact can not be conveniently expressed by a mathematical formula, and so the graph has been prepared to visually express the relation. With the Reynolds number determined as described above, this value is projected vertically until it intersects a family of curves, spreading fan wise from left to right. These curves are numbered at the extreme right edge, the numbers referring to a description of the data on which they were derived given on the table printed on this part of the chart. Thus for a very smooth pipe, such as drawn brass, or very large steel, 72" or above, curve 1 could be used. For a very small rough pipe curve 17 would be used, under which conditions the friction factor f is practically constant for all Reynolds numbers. Between these two extremes, the curve selected will depend somewhat on experience, or by referring to the table. For instance, if steel is to be used, by referring to the table it will be seen

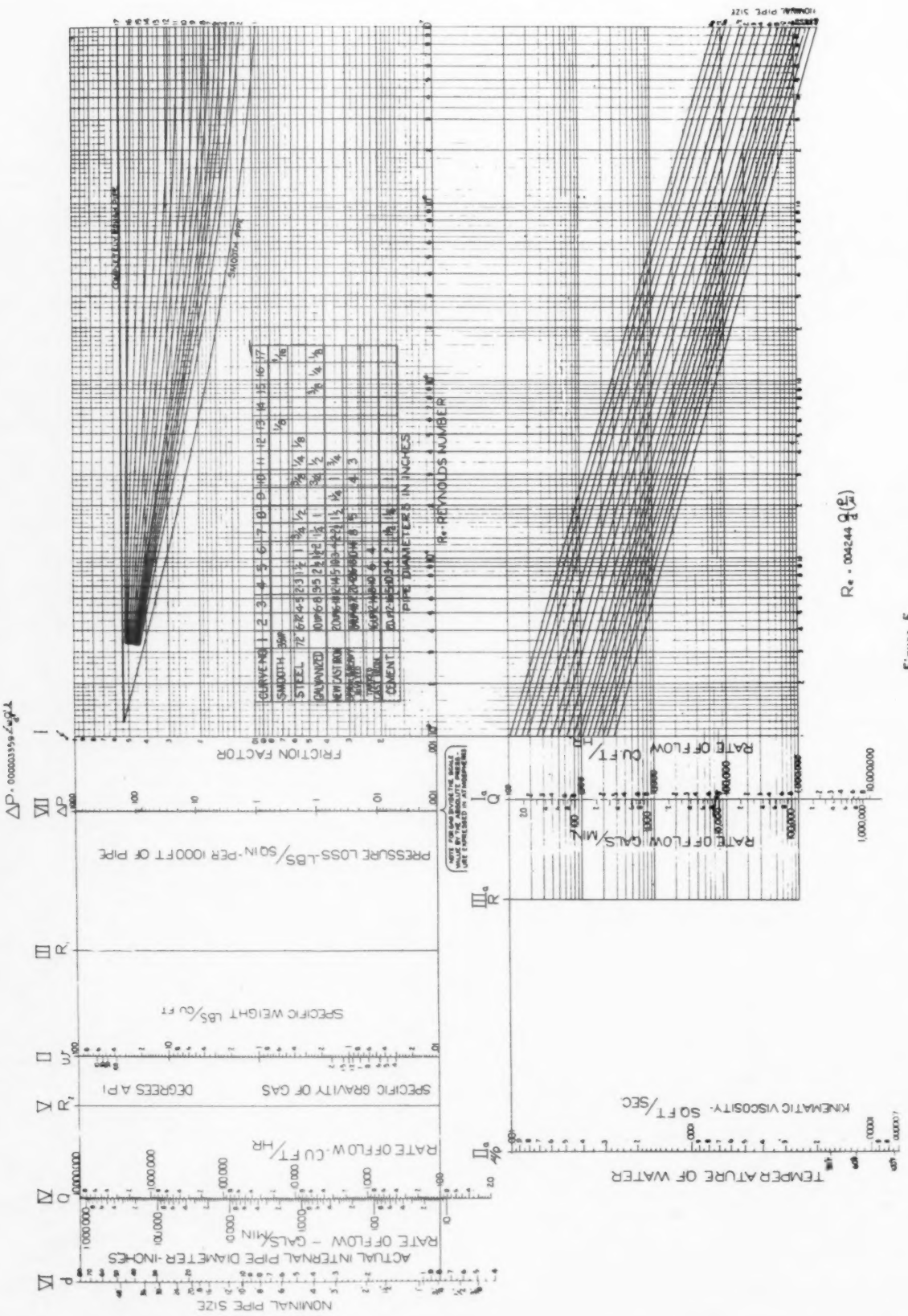
R = REYNOLDS NUMBER
PIPE DIAMETER IN INCHES
FRICTION FACTOR
PRESSURE LOSS-LBS/SQ IN-PER 1000 FT OF PIPE
SPECIFIC WEIGHT LBS/CU FT
SPECIFIC GRAVITY OF GAS
DEGREES A PI
RATE OF FLOW-CU FT/HR
RATE OF FLOW - CALS/MIN
ACTUAL INTERNAL PIPE DIAMETER-INCHES
NOMINAL PIPE SIZE
RATE OF FLOW CU FT/
RATE OF FLOW CALS/MIN
TEMPERATURE OF WATER
KINEMATIC VISCOSITY- SQ FT/SEC

Figure 5

that 2 or 3 inch pipe can use curve 4; 4 or 5 inch curve 3; 6″ or above curve 2. For cast iron 5″ to 10″ pipes would use curve 5, and larger size curves 4, 3 or 2 as the size increases. By using this visual method of determining friction factor, the experience upon which the curves were plotted can be usefully employed.

The friction factor f to be used is found by projecting horizontally to the left the point of intersection of the Reynolds number value (vertical line), with the friction factor line, I. In this way the friction factor for the actual flow conditions can be obtained, and used in our flow formula.

The problem now becomes one of substituting this friction factor into the general equation 7 to obtain the pressure loss. The left top section of the graph is an alignment chart on which the substitution in the equation can be graphically carried out.

Equation 7 in its existing form $p_1 - p_2 = \frac{4 f \rho s^2 l}{D}$, we have seen previously is dimensionally correct. In assigning numerical values to arrive at a workable equation the following steps are taken.

Let $Q'$ = rate of flow in cubic feet per second.

Then
$$S = \frac{Q'}{\frac{\pi D^2}{4}} \qquad (10)$$

However, rate of flow in cubic feet per hour is more convenient.

Let Q = rate of flow in cubic feet per hour

$$Q' = \frac{Q}{3600}$$

Diameter is usually expressed in inches rather than feet.

Let d = diameter in inches

and D = diameter in feet

Then $D = \frac{d}{12}$

Substituting in equation (10)

$$S = \frac{\frac{Q}{3600}}{\frac{\pi \quad d^2}{4 \times 144}} = .050929 \frac{Q}{d^2} \qquad (11)$$

In equation 7, $\rho$ appears as density. In arriving at numerical units this value is usually w, specific weight; $\rho$ is equal to $\frac{w}{g}$, with the numerical value of g being 32.174, so we will substitute for $\rho$ its equivalent $\frac{w}{32.174}$.

Also in actual work, pressure is normally expressed in pounds per square inch P, instead of p, pounds per square foot used in the development of equation 7.

$$p = 144\ P$$

Substituting

$$144\ (P_1 - P_2) = 4f \times \frac{w}{32.174} \times \frac{.050929^2\ Q^2}{d^4} \times l \times \frac{l}{\frac{d}{12}}$$

$$P_1 - P_2 = \frac{4 \times .050929^2 \times 12}{144 \times 32.174} \times \frac{f\ w\ Q^2\ l}{d^5}$$

$$P_1 - P_2 = .00002687 \frac{f\ w\ Q^2\ l}{d^5} \qquad (12)$$

In actually presenting pipe flow data there has been a wide divergence in the constants used, depending upon the practice of each investigator. Any system of units is satisfactory, providing they are consistent and fit the experimental data. The equation (12) is the one originally developed and widely used; it agrees in every way with the original work of Stanton and Pannell, and also Lea, who were among the early experimenters. However, many experimenters expressed the pressure loss in velocity head, and in deriving the friction relation obtain values of f which differ numerically only from the values of f which can be derived in equation 12. Much of the data has been presented on this basis, and in order to maintain similarity and consistency in units with these later experiments, it is advisable to change the constant .00002687. If we divide the constant by 8, we will convert the numerical values of f into the same values as used by many of the later experimenters. This is of course permissible, providing the results agree with the experimental data, since any change in the numerical value of the constant merely changes the numerical value of f. Then to maintain uniformity with constants usually presented in this type of work,

$$P_1 - P_2 = \frac{.00002687}{8} \frac{f\ w\ Q^2\ l}{d^5}$$

$$P_1 - P_2 = .000003359 \frac{f\ w\ Q^2\ l}{d^5} \qquad (13)$$

The alignment chart given in the upper left hand section of Fig. 4 is based upon this equation. In the actual derivation of this curve, the following values of the variables are used.

$P_1$ = initial pressure in pounds per square inch

$P_2$ = final pressure in pounds per square inch

w = specific weight in pounds per cubic foot

Q = rate of flow in cubic feet per hour

$l$ = length of line in feet

d = diameter of line in inches.

To facilitate use of the formula and graph, Table 1 gives the values of w for the more common fluids. Also value of the factor $d^5$ is given in Table 2 for the more common actual internal pipe diameters.

*(For Tables see page 61)*

In computing the pressure loss, once the friction factor f has been determined, as explained above, the following procedure should be followed. Connect the value of the friction factor as given on line I with the specific weight of the fluid, given on line II. From the intersection of this line with Reference line $R_1$, at III, connect with the rate of flow in cubic feet per hour at IV. From the intersection of this line with Reference line $R_2$ at V, connect with the pipe diameter in inches on Scale VI. Where this line intersects line VII, we can read the pressure loss in pounds per square inch for 1000 feet of pipe.

In the case of gases, where the rate of flow is normally expressed in cubic feet per hour, and the specific gravity is given (being the density as compared to air, both air and gas being at standard conditions of 60° temperature and 14.7#/sq. in. pressure) the following procedure is used. Connect the value of f as determined, with the specific gravity of the gas as given on the scale appearing at the lower left section of line II. The value used here is the true specific gravity. Connect the intersection of this line and $R_1$ (III) with the value of Q on line IV. Here use the value of Q which expresses the volume in cubic feet per hour at atmospheric (or close to atmospheric) pressure. Connect the intersection of this line and $R_2$ (V) with the value of the pipe diameter on scale VI. The intersection of this line with VII is given a value which must be divided by the pressure of the gas expressed in atmospheres to give the correct pressure loss.

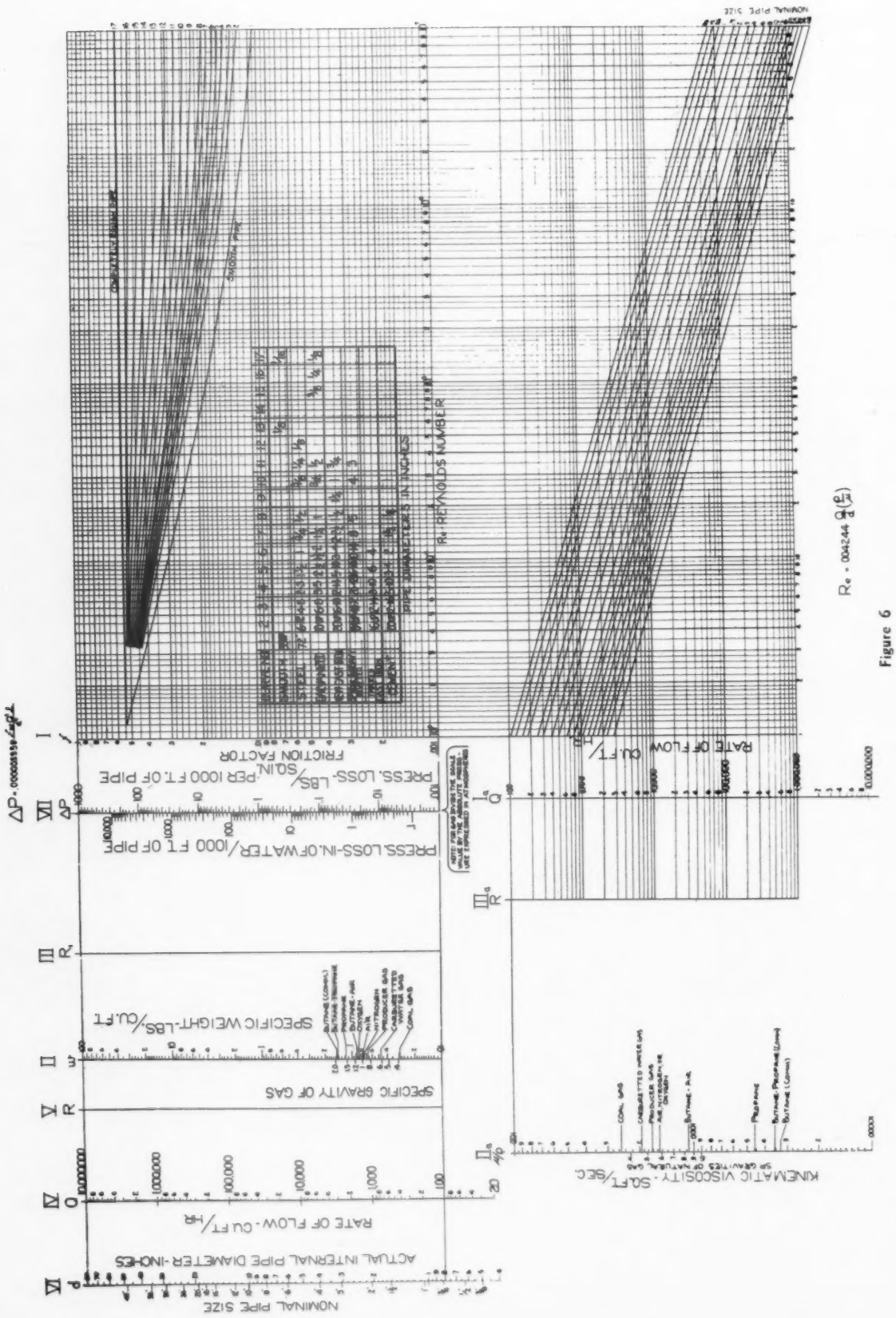
NOMINAL PIPE SIZE
ACTUAL INTERNAL PIPE DIAMETER-INCHES
RATE OF FLOW - CU.FT/HR
SPECIFIC GRAVITY OF GAS
SPECIFIC WEIGHT-LBS/CU.FT
PRESS. LOSS-IN. OF WATER/100 FT. OF PIPE
PRESS. LOSS-LBS/SQ.IN. PER 1000 FT. OF PIPE
FRICTION FACTOR
RATE OF FLOW CU.FT/
KINEMATIC VISCOSITY - SQ.FT/SEC.
Re = 0.04244 q/d(ρ/μ)
Re = REYNOLDS NUMBER
PIPE DIAMETERS IN INCHES
SMOOTH PIPE
COMMERCIAL STEEL
NOTE: FOR GAS OTHER THAN AIR DIVIDE THE SCALE VALUE BY THE SPECIFIC GRAVITY OF THE GAS AS TABULATED ABOVE

Figure 6

**Table 1. Specific Weights and Kinematic Viscosity**

| * Flowing Fluid | Specific Weight lb./cu. ft. | Kinematic Viscosity × $10^4$ ft.²/sec. | Reciprocal of Kinematic Viscosity × $10^{-3}$ |
|---|---|---|---|
| Air | .07636 | 157.2 | 6.36 |
| Nitrogen (Atmospheric) | .07423 | 156.7 | 6.38 |
| Nitrogen (Chemical) | .07386 | 157.5 | 6.34 |
| Oxygen | .08440 | 159.1 | 6.29 |
| Propane | .1193 | 44.3 | 22.6 |
| Propane (Commercial) | .1161 | 46.8 | 21.4 |
| N-Butane | .1597 | 30.4 | 32.9 |
| Iso-Butane | .1579 | 30.5 | 32.8 |
| Butane (Commercial) | .1489 | 33.0 | 30.3 |
| Acetylene | .0696 | 95.8 | 10.4 |
| Butane-Propane (Commercial) | .1419 | 35.3 | 28.3 |
| Butane-Air | .0888 | 108. | 9.29 |
| 0.60 Gravity Natural Gas | .04582 | 151. | 6.64 |
| Coal Gas | .02973 | 255. | 3.93 |
| Carbureted Water Gas | .04757 | 196. | 5.11 |
| Producer Gas | .06549 | 171. | 5.86 |
| Water—39.1° F. | 62.43 | 16.9 | 59.3 |
| 60° F. | 62.37 | 12.2 | 82.2 |
| 100° F. | 62.00 | 7.39 | 135. |
| 150° F. | 61.20 | 4.76 | 210. |
| 212° F. | 59.83 | 3.19 | 314. |
| Oil—45° API & 50 SSU | 50.00 | 79.6 | 12.6 |
| 35° API & 100 SSU | 53.00 | 222. | 4.50 |
| 18° API & 200 SSU | 59.03 | 466. | 2.15 |

** Values based on 60° F. temperature and 14.7 lb./sq. in. absolute pressure.*

**Table 1a. Specific Weight and Kinematic Viscosity for Saturated Steam**

| Temp. ° F. | Pressure lb./sq. in. abs. | Specific Weight lb./cu. ft. | Kinematic Viscosity × $10^4$ ft.²/sec. | Reciprocal of Kinematic Viscosity × $10^{-3}$ |
|---|---|---|---|---|
| 212 | 14.70 | .0373 | 229. | 4.36 |
| 250 | 29.8 | .0724 | 129. | 7.77 |
| 300 | 67.0 | .1547 | 68.2 | 14.7 |
| 350 | 134.6 | .2992 | 40.7 | 24.5 |
| 400 | 247. | .5367 | 26.9 | 37.2 |
| 450 | 423. | .9097 | 19.2 | 52.0 |
| 500 | 681. | 1.482 | 14.5 | 68.9 |
| 550 | 1045. | 2.358 | 11.3 | 88.5 |
| 600 | 1543. | 3.748 | 8.79 | 114. |
| 650 | 2208. | 6.188 | 6.49 | 154. |
| 700 | 3094. | 13.14 | 3.66 | 273. |
| 705.4 | 3206. | 19.88 | 2.46 | 406. |

**Table 2. Standard Steel Pipe***

| Pipe Size | Internal Diameter in Inches d | $d^4$ | Pipe Size | Internal Diameter in Inches d | $d^4$ |
|---|---|---|---|---|---|
| ¼ | .622 | .09310 | 12 | 12.090 | 258,300. |
| ¾ | .824 | .3799 | 12 | 11.938 | 242,470. |
| 1 | 1.049 | 1.2702 | 14 | 13.126 | 389,600. |
| 1¼ | 1.380 | 5.005 | 14 | 12.500 | 305,200. |
| 1½ | 1.610 | 10.818 | 16 | 15.00 | 759,400. |
| 2 | 2.067 | 37.73 | 16 | 14.314 | 600,900. |
| 2½ | 2.469 | 91.75 | 18 | 16.876 | 1,368,800. |
| 3 | 3.068 | 271.8 | 18 | 16.126 | 1,090,500. |
| 3½ | 3.548 | 562.2 | 20 | 18.814 | 2,357,000. |
| 4 | 4.026 | 1,057.7 | 20 | 17.938 | 1,857,200. |
| 5 | 5.047 | 3,275. | 24 | 22.626 | 5,930,000. |
| 6 | 6.065 | 8,206. | 24 | 21.564 | 4,663,000. |
| 8 | 8.071 | 34,250. | 30 | 29.00 | 20,510,000. |
| 8 | 7.981 | 32,380. | 30 | 28.75 | 19,642,000. |
| 10 | 10.136 | 106,990. | | | |
| 10 | 10.020 | 101,000. | | | |

** Dimensions of standard wrought iron pipe are very close to those of steel pipe.*

**Table 2a. Cast Iron Pipe**

| Pipe Size | * Internal Diameter in Inches d | $d^4$ | Pipe Size | Internal Diameter in Inches d | $d^4$ |
|---|---|---|---|---|---|
| 4 | 3.96 | 973.8 | 24 | 24.14 | 8,198,000. |
| 6 | 6.01 | 7,841. | 30 | 29.98 | 24,220,000. |
| 8 | 8.11 | 35,080. | 36 | 35.99 | 60,380,000. |
| 10 | 10.06 | 103,040. | 42 | 42.01 | 130,850,000. |
| 12 | 12.06 | 255,100. | 48 | 48.00 | 254,800,000. |
| 14 | 14.08 | 553,400. | 54 | 53.98 | 458,300,000. |
| 16 | 16.10 | 1,081,800. | 60 | 60.08 | 782,800,000. |
| 20 | 20.12 | 3,297,000. | | | |

** This is the average internal diameter of the four standard weights which do not vary over ± .14 in. in any one size.*

The chart as prepared in Figure 4 is applicable to all fluids, whether liquids or gases. Care must be exercised, of course, to see that the proper units are used throughout the work, and that the results are accurately interpreted. A confusing situation may arise in the use of any flow formula in computing the flow of gas, when the volume is expressed in cubic feet per hour at standard conditions of pressure and temperature, and not at existing conditions in the gas. One method to use in such an event is to transform the volume into cubic feet at existing conditions, use the weight of the gas at actual conditions, and the pressure loss so calculated will be the true pressure loss.

The other method as suggested above is to use the volume at standard conditions, use the weight of gas per cubic foot at standard conditions, and carry through the computation up to pressure loss. The pressure loss as used from the scale must be multiplied by $\frac{14.7}{P}$ to arrive at a true pressure loss.

It may be desirable to modify the general flow formula as shown in Fig. 4, to simpler forms to be used with special fluids, such as water, or low pressure gases.

Fig. 5 is designed for use with water only, and has scales which correct for temperature of the water. Table II gives the value of w — weight of water per cubic foot to be used for different temperatures. Also for convenience, the rate of flow is expressed in gallons per minute.

Fig. 6 is designed for low pressure gas such as used in fuel gas distribution systems where the pressure is usually kept down to a few ounces above atmospheric pressure. In cases of this type the specific gravity of the gas can be used directly on the chart for determining the Reynolds number and also on scale II. The pressure loss is read directly from scale VII, and has a scale to read in inches of water head, as well as pounds per square inch.

*Part 2 of Mr. MacLean's article will appear in the June issue of the* JOURNAL.—*Ed.*

# Book Reviews

*Graphic Routes to Greater Profits, by John W. Esterline. Published by Esterline-Angus Company, Indianapolis, Ind., 1938. 320 pages, illustrated. Price $3.00 per copy.*

A book on the use of graphic instruments in increasing the productive capacity and the efficiency of industry. This is a volume of experience rather than opinion. There are more than 250 case studies, each covering a distinct problem, giving the procedure followed, the graphic charts obtained and the solution reached.

The introductory section comprises thirty pages, and is divided into three chapters, under the captions "The High Cost of Inefficiency," "What Graphical Representation Means" and "Classification of Industrial Problems." The remainder of the book is in five divisions,—"The Problems of Power,"—"The Problems of Machines,"—"The Problems of Processes,"—"The Problems of Men,"—"Research and Special Problems." The case studies throughout the 19 chapters are numbered serially, and are carefully cross-indexed.

This volume is a practical contribution to the art of applying the scientific method to the conduct of industry. It discloses the modern technique of critical examination and diagnosis of industrial operations. It is interesting reading because from beginning to end, the author has endeavored not only to impart information, but to spur the reader to a continuous re-appraisal of his methods and achievements.

*Asphalts and Allied Substances, Fourth Edition, by Herbert Abraham. D. Van Nostrand Company, Inc. 1938. 1491 pages. Price $2.50.*

This exhaustive treatise has been written for those interested in the fabrication, merchandising and application of bituminous products. It embraces: (1) Methods serving as a guide for the chemist engaged in testing and analyzing raw and manufactured products; (2) data for assisting the refinery or factory superintendent in blending and compounding mixtures, and (3) the principles underlying the practical application of bituminous products.

Chapters on "Coal Tar and Coal-Tar Pitch" and "Water-Gas and Oil-Gas Tars and Pitches" will be of particular interest to the works chemists and operating men in our industry. Of at least equal interest to those who have to deal with pipe coatings will be the general discussion of bituminous compounds and how they are affected by weathering.

*Automatic Gas Fired Storage Type Water Heaters, by J. M. Krappe. Research Series No. 58, Engineering Experiment Station, Purdue University. September, 1937. 72 pages. Price 25 cents per copy.*

This report covers an investigation of the gas-fired, storage-type water heater, each heater being equipped with a storage tank of specified capacity and complete automatic controls. Both the low-input type and the quick-recovery type were tested and are reported on.

This is an important contribution to the literature on gas water heating and should be in the hands of all executives, engineers and sales managers who have to do with this subject.

*Procedure Handbook of Arc Welding Design and Practice, Fifth Edition. Published by The Lincoln Electric Company, Cleveland, Ohio, 1938. 1012 pages; 1243 illustrations including photographs and drawings. Price in the United States $1.50 per copy, post paid. Foreign $2.00 per copy.*

This handbook is well known to all who have contact with arc welding work as the complete and authoritative reference guide on the subject. This most recent edition takes into account all of the recent developments in arc welding, including new or revised information on the following subjects: A.W.S. Weld Symbols, Welding Costs, High Speed Automatic Welding, High Tensile Steels, Cold Rolled Steel, Medium High Carbon Steel, Chrome Steel, S.A.E. Steel Numbering System, A.W.S. Filler Metal Specifications, Machine Design, Structural Design; also new welding applications throughout the many industrial fields.

The eight sections of the book cover the following subjects:

Part I—Welding Methods and Equipment. (24 Pages—12 Illustrations.)

Part II—Technique of Welding. (85 Pages—96 Illustrations.)

Part III—Procedures, Speeds and Costs for Welding Mild Steel. (81 Pages—93 Illustrations.)

Part IV—Structure and Properties of Weld Metal. (14 Pages—22 Illustrations.)

Part V—Weldability of Metals. (93 Pages—41 Illustrations.)

Part VI—Designing for Arc Welded Steel Construction of Machienry. (154 Pages—232 Illustrations.)

Part VII—Designing for Arc Welded Structures. (215 Pages—281 Illustrations.)

Part VIII—Typical Applications of Arc Welding in Manufacturing, Construction and Maintenance. (289 Pages—466 Illustrations.)

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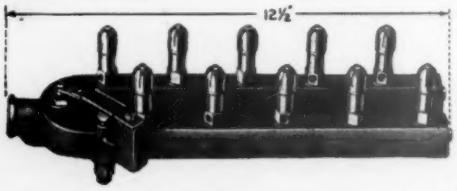


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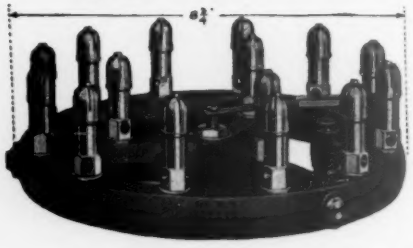


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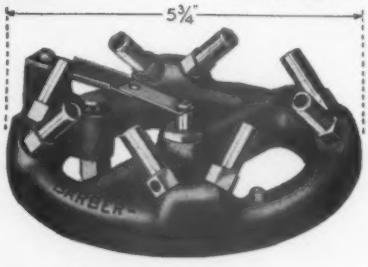


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# Servicing Domestic Appliances

## Part 2—Oven Burners—Range Connections

By
**E. W. Christell**
Junior Engineer
The Peoples Gas Light and Coke Company
Chicago, Illinois

### Low Temperature Oven Burner Adjustments

The new low temperature oven burner is about one-half the size of the old oven burner and contains about one-half the number of ports. However, the ports on the burner are larger and consequently they permit an equal or a larger volume of gas to be burned. In the past it has been the practice to adjust the inner cone flames on the oven burner to approximately ½ an inch. However, in order to burn the same volume of gas on the new low temperature oven burners as on the old style burners it is now necessary to adjust the inner cone flames to approximately ¾ to ⅞ of an inch, otherwise the over burners would be undergassed, as illustrated in figures 10 to 13.

At the present time many of the range manufacturers advertise the preheating speed of their range ovens. This we have found you cannot duplicate in the field, since these preheating speeds have been determined by a potentiometer and thermocouple. Several of the present oven thermometers now on the market have been found to lag about 100° F. during the heating up tests in the oven and to usually register about 20° F. lower than the potentiometer when maintaining a constant oven temperature. Cases have been encountered from time to time where the customer claims that the oven does not preheat as fast as advertised. In checking into cases of this kinds it has been found that standard oven thermometers have been used by the customer to check the temperature rise and the heat control calibration. Consequently due to the lag in the thermometer it will take 3 or 4 minutes longer before it will register the oven temperature within approximately 20° of the actual temperature. The lower temperature reading obtained with the oven thermometer, when maintaining a constant oven temperature, may be partially due to the base of the thermometer interfering with the natural circulation of the air in the oven. Complaints of this kind necessitate a satisfactory explanation on the part of the serviceman and he should be qualified to give such an explanation if necessary.

In order to enable every appliance serviceman to check the preheating speed of the oven so as to be assured that the adjustment of the gas input to the over burner is satisfactory, it is felt that the time required to preheat the oven should be determined with a standard oven thermometer for all ranges sold by the utility. This preheating speed should be determined at 350° F. and at 500° F. with the heat control set at 550° F. and prepared in table form so that this information can be carried by every serviceman. The preheating speed for 350° will then enable the serviceman to reset the oven heat control to 400° F. and check the calibration of the control as soon as the preheating speed has been checked.

The Btu input for all range ovens is now clearly stamped on the name plate and if necessary the input can be clocked at the meter. This it is believed is not necessary if the aforementioned steps are followed in checking the range oven burner adjustment.

### Prompt Installation

Enough importance cannot be placed on providing the customer with satisfactory appliance adjustments; however, this service should be augmented by insuring immediate delivery and the proper connection of the gas appliance upon the consummation of a sale. In the case of the modern gas range, our company has found it desirable to work out a routine whereby our service shops are notified of the approximate time of day that the range will be delivered to the customer's premises by our warehouse. The fitter will call at the customer's premises at the designated time and connect, adjust and test the gas range. The customer is also given verbal instructions at this time on the operation and care of range. Upon completion, a follow-up inspection is made by the fitting inspector.

This procedure has resulted in the customer obtaining the immediate service of their new modern automatic gas range within two hours of the delivery. It has also left such a vivid picture in the customer's mind as to the prompt service which was rendered at the time of the range installation, that it has brought many comments of praise and has also aided in the sale of gas ranges to other customers.

### Servicing Difficulties

The modern gas range has not only brought about new burner adjustments but has also introduced many new servicing difficulties, which have been experienced by utility companies throughout the country. It is felt that these difficulties should be brought to the attention of the service departments so that an effort can be made to not only instruct their servicing organization of these cases, but so an effort can be made to correct these conditions in the future through the A.G.A. Appliance Servicing Committee, etc.

The servicing difficulties which have been encountered by various utility companies throughout the country are as follows:

1. In many cases it has been found necessary to disconnect the gas range and pull it out from the wall in order to service the oven orifice, oven pilot adjusting screw, tubing connections, burner gas valves, electric clock, oven heat control, oven or broiler door springs, lift top cover springs, etc. In cases where an orifice adjustment is involved, the burner cannot be checked until range is reconnected. Every effort should be made by the manufacturer to construct range so that as many adjustments as possible are accessible from the front of the

*From paper presented at Fifteenth Annual Distribution Conference American Gas Association, Cincinnati, Ohio, April 4, 5, and 6, 1938.*

range, without requiring the range to be disconnected.

2. The burner gas valves and valve handles are probably replaced more than any other part of the gas range, yet it has been found that there are still many ranges on the market where it takes practically from 30 to 45 minutes to remove the front panel and its component parts before a gas valve can be cleaned and greased or replaced. The manifold panels on the ranges should be fastened so that they can be removed within 3 or 4 minutes.

3. Many gas ranges are found in the field which are assembled very poorly. Various public utilities have found ranges installed with the top burners out of line, sagging, not properly lined up with the insta-flame lighter, not equipped with the proper burner heads or orifices, and the lighter ports incorrectly sized. The insta-flame lighter has been found improperly centered, the flash tubes insecurely fastened and in many cases too short to provide satisfactory burner ignition. Some have even reported that the oven burner lighter tube has fallen out of place in many cases where the oven bottom was removed for cleaning by the customer.

Oven doors have been found to stick closed after customer had placed a roast or cake in oven due to the expansion of various parts of oven. This same condition has also occurred on broiler and utensile doors. In a number of cases customers have complained of cooking vessels sliding off the top grates. This condition was found to be caused by the grates not being level. Various panels of the range have been found improperly assembled, and oven doors warped, loose or not closing properly. Many other defects have been found, all of which have had a material effect in discouraging the customer of the advantages of the modern range until conditions which have been found were corrected and the customer's confidence regained. Service difficulties of this kind bring out the vital necessity of the manufacturer assembling the gas range with precision so as to guard against the above conditions.

4. With the introduction of the modern range, considerably more effort must be expended by the serviceman or fitter at the time of installation or service call to insure proper fitting of oven doors and lift top covers. On the old style ranges, the oven was usually above the top burner cooking surface and a leaking or ill-fitting oven door would not in most cases interfere with the proper combustion of the gas on the top burners. On some of the new apartment model ranges, a leaking oven door will sometimes permit the flue products from the oven to be drawn up into the burner compartment, thereby interfering with the proper combustion of the gas. This condition is considerably more critical on ranges equipped with individual top burner aeration bowls controlling the secondary air to each burner, because of the flue action which this opening around the burner creates. Where flue products have been found leaking into the top burner compartment, the flames would blow and lift off the burner ports very badly.

On the old ranges, the entire top burner compartments were open and would in most cases not be greatly affected by leakage from the oven door.

The lift top cover has improved the looks of the gas range considerably, but in many cases has been found to be poorly constructed and easily put out of line. The lining up and fitting of the lift top covers and over doors require careful adjustment by the servicemen. It is felt that considerable improvement can be made in the design of the lift top cover and the oven door so that they will remain properly fitted for a longer period of time. The servicemen should be given thorough instructions as to the fitting of oven doors and lift top covers.

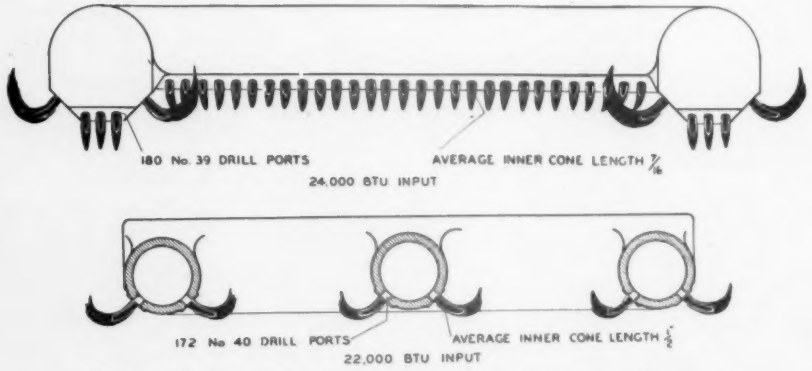

180 No. 39 DRILL PORTS
AVERAGE INNER CONE LENGTH 7/16
24,000 BTU INPUT
172 No. 40 DRILL PORTS
AVERAGE INNER CONE LENGTH 1/2
22,000 BTU INPUT

**Fig. 10 Typical old style oven burners with correct flame adjustment.**

5. A number of complaints have been experienced by several gas companies due to delayed ignition of the range top burners without simmer from the insta-flame pilot. This complaint has resulted even though burner ignition occurred within the 4 second time limit set up in the A.G.A. range approval requirement. This delay caused the gas which accumulated under the cooking vessel to flare out from underneath it several inches when ignited by pilot. The ignition of the gas has usually been found to be accompanied with a puff which proved highly objectionable to the customer. Complaints of this kind were most pronounced on burners not equipped with simmer features. In one case it was reported that it was necessary for the manufacturer to make changes in the burner head in order to reduce the ignition time to within 2 seconds so as to eliminate the above objection. It is believed that the A.G.A. requirements for complete automatic ignition of the gas at any burner, or combination of burners, simmering burner included, should be reduced to possibly 2 seconds or less after the burners have been turned on full in order to eliminate the possibility of any repetition of such cases as mentioned above. Where simmer-save burners are used it is believed that the customer should be instructed to light the simmer burner first.

6. The lighting of the oven burner is still a very objectionable feature on the modern gas range. It is necessary that the customer co-ordinate every one of her movements when lighting the oven burner. The lighted match must be held away from the lighting hole or burner until the oven valve has been turned on full and a second or two lapsed for the oven burner to fill with gas. Then the lighted match must be applied.

It is generally felt that the standard of oven lighting should be improved upon. On some ranges, it is necessary to light the oven burner through a lighting hole in the oven bottom and on others, it is necessary for the customer to get down on her knees in order to light the burner from the broiling compartment. There can be no doubt that in order to simplify this procedure as far as the customer is concerned, a standard method of lighting the oven burner should be adopted by all manufactur-

ers. Many believe that the burner should only be lighted from a lighting hole placed in the oven bottom. This hole to be located so that it can easily be seen and so it is very accessible to the customer. The lighting hole should provide ignition of the oven burner when on the by-pass or the maximum flame. Most companies feel that some means should also be provided to enable the customer to see whether the oven burner is lighted or not from a standing position.

Adequate lighting instructions should also be placed alongside the lighting hole in the form of an engraved plate or in the enameled finish of the oven bottom. This information, without question, is vitally essential to the safe lighting of the oven burner. These instructions should provide any individual who may have occasion to use the oven on the range with the correct lighting instructions. On many occasions it has been found that servicemen have been called out on service calls merely to find that the customer did not understand how to light the oven burner. When these cases were checked into it was found that a member of the family had been instructed at the time the range was connected, but had failed to pass that information on to other members of the household. Cases of this kind bring out the urgent need of written oven lighting instructions to the customer.

7. On the old style gas range the operating instructions given to the customer by the fitter and serviceman at the time of installation were relatively simple. However, on the modern automatic ranges, considerably more instructions must be given to the customer, especially on the following matters:

(1) Lighting of top burners and correct burner adjustment.

(2) Procedure for the removal and cleaning of the top burners without molesting air shutter adjustment or misplacing burners.

(3) Purpose of simmer burner and its operation.

(4) Lighting of oven burner and operation of oven gas cock.

(5) Lighting of broiler burner.

(6) Instructions on the operation of oven heat control with thermal eye or equivalent.

(7) Operation of electric automatic oven timing device.

(8) Operation of oven timer.

(9) Instructions on deep well cooker, broiler, etc.

(10) Care of enamel.

(11) Care of aluminum broiling grill.

These instructions should be given to the customer at the time of the installation of the range, but in many cases the actual user of the range is not at home to receive these instructions. In view of this condition, it is felt that a booklet should be published by each manufacturer covering all of the points previously mentioned in detail and when necessary should include drawings to illustrate the instructions very plainly. This booklet should also include information concerning the modern methods of cookery. It is felt that this information, compiled in a single pamphlet, would be well received by the customer and that it would be kept by them for reference purposes.

Some manufacturers are at the present time delivering pamphlets and cards of various kinds with their range, but most of this information is on cooking. In cases where information is sent along on the mechanical operation of the heat control or burner adjustment it is generally of no value to the customer. In some cases, cards have been found with instructions to the customer on the care of the enamel but they have ordinarily been so small that the customer seldom reads them.

8. A number of ranges have been found in the field with the oven burner orifice and primary air shutter located in the combustion chamber of the oven. With the oven burner operating it is practically impossible in many cases to adjust the burner without sustaining a burn. In some cases it is absolutely necessary to remove the oven burner in order to gain access to the orifice and air shutter. Simplified service cannot be obtained unless cases of this kind are eliminated.

9. In general, it is found that in many cases it is essential that special wrenches of all kinds be carried by the servicemen in order to enable them to gain access to the orifice adjustments without removing the gas burners. In many cases the manufacturer has supplied special wrenches with each range sold. It is believed that the manufacturer, as well as the service organization, is put to unnecessary expense because of this inaccessibility of orifice adjustments. It is felt that this condition could be overcome considerably by having the manufacturer and the A.G.A. laboratory test all adjustments and appliances with the standard tools carried by the servicemen in the field as much as possible. Such standard tools to consist of bent nose pliers, fine nose crescent wrench, midget and 6 inch screw driver, and a 6 and 10" pipe wrench. If a special wrench is needed, it is believed it should be designed so that it would meet the requirements of all ranges rather than just one range.

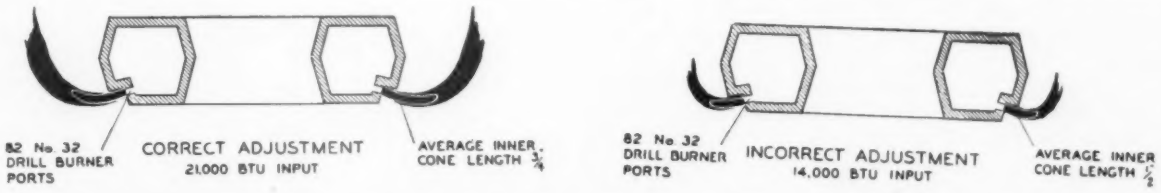

82 No 32 DRILL BURNER PORTS
CORRECT ADJUSTMENT
21,000 BTU INPUT
AVERAGE INNER CONE LENGTH 3/4
82 No 32 DRILL BURNER PORTS
INCORRECT ADJUSTMENT
14,000 BTU INPUT
AVERAGE INNER CONE LENGTH 1/2

**Fig. 11 Effect of correct and incorrect flame adjustments on heat input to new style low temperature oven burner.**

## Semi-Rigid Flexible Tubing for Range Connections

The connecting of the modern automatic gas range between cabinets, walls, etc., has become a problem which only a few manufacturers have overcome on their 1938 lines. The manifold connections of the average range will be found to terminate at any point in the back panel of the range. If the range is installed so that there is ample room for the fitter to gain access to the gas line from either end of the range, the connection can usually be made quite easily. However, if the range is installed beteween cabinets, which

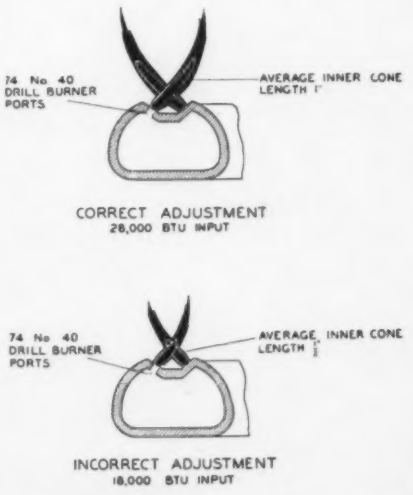

74 No 40 DRILL BURNER PORTS
AVERAGE INNER CONE LENGTH 1"
CORRECT ADJUSTMENT
28,000 BTU INPUT
74 No 40 DRILL BURNER PORTS
AVERAGE INNER CONE LENGTH 1/2
INCORRECT ADJUSTMENT
18,000 BTU INPUT

**Fig. 12 Effect of correct and incorrect flame adjustments on heat input to new style low temperature over burner.**

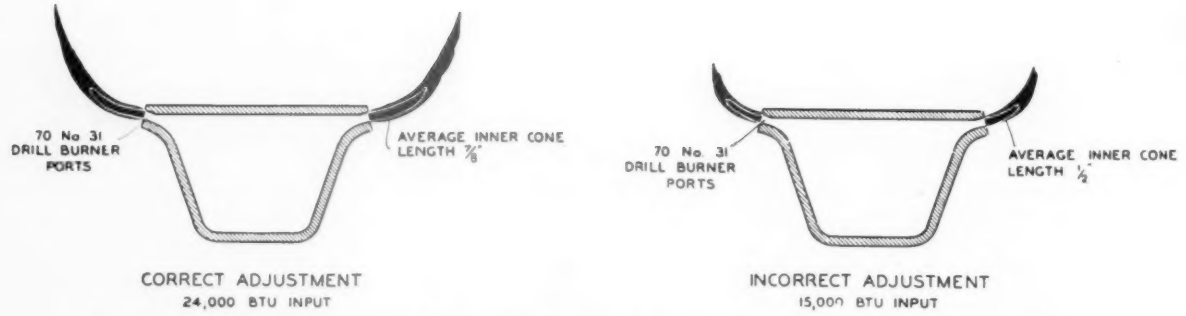



**Fig. 13 Effect of correct and incorrect flame adjustments on heat input to new style low temperature oven burner.**

is often the case, it is extremely difficult in some cases to connect the gas line, especially where the manifold connection is near the bottom of the range.

In attempting to find a way in which to connect the range with as little trouble as possible, the attention of a number of gas companies has been called to some of the semi-rigid flexible copper and aluminum tubing connections which are on the market for connecting gas ranges.

Many companies and dealers have already accepted this type of connection, but there are also a number of other utilities who are still reluctant to approve this type of connection until it is universally accepted.

It has generally been believed that if a semi-rigid tubing connection is used, the range will in all probability be moved by the customer without disconnecting tubing when it is necessary, to paint or clean behind the range. Practical tests have been conducted in the past on the use of the semi-rigid tubing as a gas connection, and it is felt that some of the conclusions which were formulated as a result of these tests would be of interest to the industry.

The practical tests on the semi-rigid connections were made after properly connecting the range, by pulling the range away from the wall 12 different times and then pushing it back in position. The nature of the damage to the tubing was then determined, and it was found to vary according to the type of connection made. However, in almost each case the tubing kinked or cracked open at either the union nut connections or at any bend made in the tubing. It was also found that there was a tendency for the flared joint to leak and begin to pull out from the union nut. Some of the conclusions which were reached as a result of the practical tests conducted are as follows:

1. In order for the semi-rigid tubing to offer any advantages over the iron pipe connection, the gas range would undoubtedly have to be connected by means of tubing when it is at least 12 or 18 inches from the wall, so as to make the gas connections more accessible. By forcing ranges into position, after tubing is made up, it is possible that tubing will be kinked and gas flow restricted.

2. If tubing is used, traps may be formed by the tubing sagging on long straight or looped horizontal connections. It is the opinion of several that there might also be cases where the installer might bend surplus tubing, rather than cut it off, thereby leaving a trap in tubing.

3. Manufacturers of semi-rigid

| *Comparative Cost of Range Connection made with 5/8" Diameter Copper Tubing* | |
|---|---|
| 4 feet of 5/8" tubing @ 17c per foot | .68 |
| 2 union nuts and 1/2" straight connectors | .53 |
| 2—3/4 x 1/2" reducers @ 7c each | .14 |
| Total cost of material | $1.35 |

| *Cost of Material for Average Range Connection made with 3/4" Std. Iron Pipe* | |
|---|---|
| 4 feet of 3/4" iron pipe @ 6c per foot | .24 |
| 1—3/4" plain Elbow | .06 |
| 1—3/4" street Ell | .08 |
| 1—3/4" nipple | .04 |
| 1—3/4" union | .14 |
| Total cost of material | $ .56 |

*As will be noted, the ordinary range connection requiring 4 feet of iron pipe costs only 56 cents in comparison to $1.35 when 5/8" diameter copper tubing is used. On a material basis, the iron pipe costs are approximately 41% of the cost of copper tubing and fittings.*

TABLE I

| Flow of Gas Through— | | | |
|---|---|---|---|
| *5/8" semi-rigid tubing, 4'9" long, 0.049" wall thickness, inside diameter 0.475"* | | *1/2 Standard iron pipe, 4'9" long. Inside diameter 0.622"* | |
| Gas Rate Cubic Feet per Hour | Pressure Drop | Gas Rate Cubic Feet per Hour | Pressure Drop |
| 66 | 0.1 | 127 | 0.1 |
| 101 | 0.2 | 180 | 0.2 |
| 125 | 0.3 | 240 | 0.3 |

TABLE II

| Flow of Gas Through— | | | |
|---|---|---|---|
| *3/4" semi-rigid tubing, 3' long, 0.065" wall thickness, inside diameter 0.70"* | | *3/4" Standard Iron Pipe 3' long—Inside diameter 0.824"* | |
| Gas Rate Cubic Feet per Hour | Pressure Drop | Gas Rate Cubic Feet per Hour | Pressure Drop |
| 147 | 0.1 | 270 | 0.1 |
| 232 | 0.2 | 440 | 0.2 |

*The capacity of the 5/8" semi-rigid tubing, was found to be 125 cubic feet per hour with a pressure drop of 0.3 inches of water column. This gas flow is barely adequate to take care of a standard range with 4 top burners with simmer sections, oven and separate broiler, requiring an input of 92,000 Btu per hour on a mixed gas of a heating value of 800 Btu. If a 6 top burner range were used, the maximum demand of this range could not be supplied by the 5/8" tubing. From a capacity standpoint, only 3/4" semi-rigid tubing should be considered for range connections.*

*The above findings have consequently caused several utilities and dealers to withhold consideration of this type of connection for ranges until it can be proven that these conditions will not increase service calls.*

tubing have advocated the purchasing of tubing cut and flared in lengths varying from 6 to 36", nevertheless in many cases it probably would still be necessary to use iron pipe fittings in order to provide connections for the various lengths of tubing. The cost of the iron pipe fittings would then be in addition to the cost of the tubing and connections.

4. Where the customer or painter desires to clean or paint behind the range it is believed that he will naturally resort to the course of least resistance and pull out range from wall if connected with semi-rigid tubing. Consequently, if the range is in a position so that it can be moved, a gas leak may result due to a crack in tubing or a damaged flared joint. A kink might also result and cause a poor gas supply to range.

5. While ⅝" diameter copper tubing is more expensive than iron pipe, many feel that the amount of labor saved will offset this difference. The following costs are offered for comparison:

Out of 95 ranges recently connected, the average number of feet of pipe used per job was approximately four (4) feet. On this basis a comparison as to cost was made on ¾ inch iron pipe and ⅝" diameter copper tubing (see table).

6. On 33 out of the 95 range installations analyzed, it was found that more than 3 feet of iron pipe was required. On these jobs a total of 264 feet of pipe was used or an average of 8 feet per job. On this basis there would be approximately 34% of the range installations which would still require cutting and threading of iron pipe on the job, even though semi-rigid connections were used.

7. The flow of gas through ⅝" and ¾" diameter tubing is very low when compared with the flow of gas through ½" and ¾" iron pipe. The capacities here shown which were determined with a gas of a 0.54 specific gravity, are offered for comparison:

In conclusion, it is felt that there is one thing that we must definitely guard against very carefully, and that is the possibility of our service organizations growing stale and making appliance adjustments as a matter of course, and losing the vigor and the wholehearted desire to make precise adjustments. Furthermore, the servicemen should give the last customer's complaint of his route as much attention as he did his first call and be courteous to the customer regardless of his attitude. There should be a special effort made on the part of every serviceman to leave every customer not only well satisfied that the condition complained of has been corrected, but also satisfied that gas is the best and only fuel to use. It is honestly believed that if our service organizations are trained continuously and kept up to date on the adjustments of the latest type of modern appliances we will obtain better better customer relations through improved service and most important of all our servicemen will be better qualified to protect our prize load, domestic cooking.

### McCance Elected V.P. of Philadelphia Co.

Pressly H. McCance has been elected a vice president of Philadelphia Company, according to an announcement by Frank R. Phillips, president of the company. Mr. McCance, who was formerly assistant to the president and director of personnel, has a record of many years service with the company. He entered the company's law department in December 1923, where he served until 1929 when he was made director of personnel.

### Arthur Stockstrom Elected President of American Stove Company

At a recent directors meeting of American Stove Company the following changes were made:

Louis Stockstrom, president since 1927, was named chairman, and his son, Arthur Stockstrom, was elevated from secretary to president, Associated Press dispatches stated. George E. Baker was elected secretary-treasurer and C. P. Fiske was named assistant treasurer.

S. E. Little, Cleveland, with R. K. Clark and A. F. Millikan, Chicago; and I. W. Peffly, New York were reelected vice presidents. Company's general office is in St. Louis but it has plants in Cleveland, Lorain, St. Louis, Chicago, Harvey, Ill., and Indianapolis. American Stove Company are makers of Magic Chief gas ranges.

### Stove Industry Announces Plans For Merchandising Convention

The Institute of Cooking and Heating Appliance Manufacturers, with offices in the Shoreham Hotel, Washington, D. C., announces through its Managing Director, Mr. Samuel Dunckel, a Mid-Year Convention on June 9th and 10th, at the Netherland Plaza Hotel, Cincinnati. This Convention will be devoted principally to a consideration of merchandising problems.

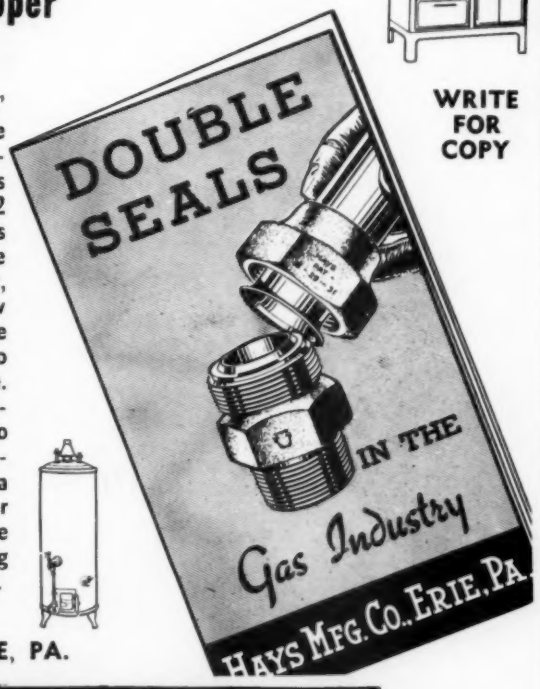
Outstanding speakers are scheduled, including Mr. J. C. Aspley, who will make the keynote address; Mr. Saunders Norvell, and Mr. Walter Teague.


**USE HAYS DOUBLE SEALS**

**For Gas Tight Copper Pipe Connections**

**You can see how the Hays' Double Seal Copper pipe connection, with its 2 machined seats (45° plus 90°) grip and hold the 2 faced flanges (45° plus 90°) of the pipe to make a positive doubly tight air, gas or liquid seal. The new folder describes how Double Seals fit into your needs to save money and time. Shows how to make permanent trouble-free main to meter copper pipe connections—Gives results of a survey on use of copper service pipe—diagrams the Hays Copper Plumbing Method. Write for copies.**

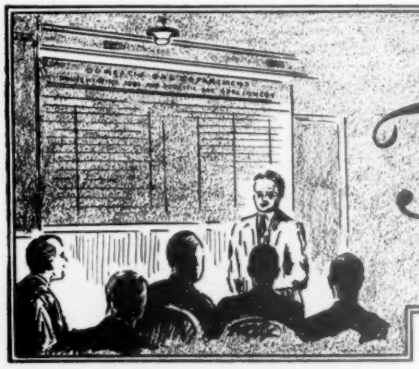





**WRITE FOR COPY**

**HAYS MFG. CO., ERIE, PA.**

**Specify HAYS DOUBLE SEALS**



# Timely Sales Chats

By William H. Matlack

When spring is still in the air and women begin to think of hot weather they also begin to think of the need for Hot Water in the home * * * That's the time to swing into action

and that is what the boys are doing, j u d g i n g from the promotion that comes to our desk * * * It's time to yank out the old furnace coil * * * To banish forever the thought so many folks have that these gadgets furnish Free Hot Water * * * Springtime is the time to provide the home with quick, abundant, automatic, gas hot water service

* * * Sell 'em now and by fall they will help you sell others * * * Naturally you can't sell this service by "Horrible Price Reductions," but you can, and we should have, for the past umpty ump years, been selling it on a basis that it works, that it is convenient, that it is essential to that thing referred to as "a more abundant life."

The initial step, and you may say it's silly to reiterate, is to decide what you want to do, how many heaters your market will absorb then and only then build a plan to sell them * * * Don't use the old "look at the good homes" idea * * * Learn from the many and various sources at your command who need and can afford Automatic Hot Water Service.

This done figure out what is going to make them conscious of the fact; what your approach is to be; how you will train your men to make this approach; what you will provide them in the way of sales training; and promotion help after they are ready to call on prospective purchasers.

Lay out your newspaper and other forms of advertising, get a tie-in display advertisement for your store window and for the floor * * * Decide on the price, the terms, the method of installation, what trade-in you will make * * * This done schedule your advertising, break it and set your forces to work * * * Check up, look for new approaches, weakness in presentation, keep an eye on your objective and one day you'll find folks buying Automatic Gas Hot Water Service * * * It must be done.

**EVERYBODY** gets a warm bath
when you have an
**AUTOMATIC GAS WATER HEATER**

There's no delayed action about hot water that's heated in an Automatic Gas Water Heater — it's right there, 24 hours a day. It keeps right on coming, too . . . continuously, for every household use. You actually pay less per gallon of hot water than by old-fashioned, inconvenient hot water heating methods — you can afford to use more hot water.

**PAY AS LITTLE AS $2.50 DOWN**
**TO INSTALL AN AUTOMATIC GAS WATER HEATER**

36 months to pay the balance. Phone our office for full information.

**NORTHERN INDIANA POWER COMPANY**

Look at the advertisements we reproduce in this section—they will provide you not only ideas for building your own advertisements but will give you an idea of how others are getting over the hurdles, what terms and plans they are using.

And if we may digress for a moment we want to say we regretfully notice that there's an epidemic of "Sickening Price Slashing" sales of gas ranges going on over the map * * * We wonder why, with the best thing that sets on the kitchen floor and cooks, the most flexible, efficient, economical cooking device

ever shown a woman, we persist in chirping; "Cheap, Cheap, Cheap"

* * * To be sure the gas range is inexpensive but it is not "Cheap." It does its stuff, it's darn good to look at, it's beautiful, it's fast, it's economical, it cooks with low temperatures, it broils as only a gas range can, it is clean, it is cool, its burners bring you a thousand heats—my oh my, why do we resort to "cheap" when we have so much to sell that the woman wants in the way of a cooking appliance.

** A spring activity that was very productive of results was a Trial Plan for the sale of automatic

$1.00 DOWN
Installs this Automatic GAS WATER HEATER in Your Home
Here Is Your Big Opportunity to Find Out What Automatic Gas Hot Water Means to Your Home
For only $1 down and $1 per month for six months you can enjoy perfect AUTOMATIC HOT WATER SERVICE. If, at the end of six months, you wish to continue having this service, you can pay the balance in 30 monthly installments.
WE ARE MAKING THIS UNUSUAL OFFER (with such attractive terms) because we know you will appreciate the many advantages automatic hot water gives you.
The LACLEDE GAS LIGHT Co.
CENTRAL 3600

*gas hot water service used by the Laclede Gas Light Company, St. Louis. This plan enabled the customer to install an automatic gas water heater in his home on a trial basis for a period of six months, after which he was privileged to return it if it proved unsatisfactory. He paid only one dollar down at the time he placed his order and only one dollar per month during the trial period. The activity was announced by newspaper advertising and employees were enlisted in a* ***big drive*** *for live leads for the salesmen to work on. Training schools were conducted for sales people prior to the opening of the drive by that old trooper-sales-trainer "Bob" Caniff, Ruudiator of Pittsburgh.*

*We applaud this advertisement from "The Queens Borough News" and commend it to gas men here and there: "Electric Cooking versus Gas Cooking."*

*There is a great deal of present interest in cooking by electricity, and occasionally our customers ask us as to its merits.*

*We as a* ***combination*** *Company sell both gas and electricity and take an impartial view of their comparative merits for cooking. We are prepared to supply service for either.*

*We approach the question from one angle only—what is best for the customer. We believe that what is best for the customer should prevail, and that* ***what is best for the customer is best for the company.***

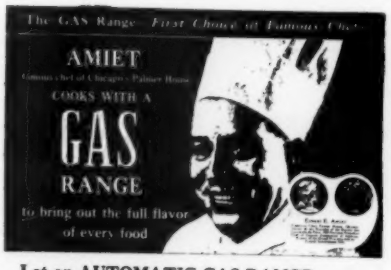
*At the present time the customer's dollar buys more heat value and more cooking satisfaction in gas. On the score of speed, flexibility, appliance and repair cost, the present advantage lies with gas.*

*We believe the improvements that are constantly being made in gas appliances, both in appearance and efficiency, will serve to increase our customers' satisfaction in their use. With these facts in mind we recommend "gas for cooking" New York Borough Gas & Electric Company, Far Rockaway, N. Y.*

*One of the finest combination sales manual catalogs it has been our pleasure to get hold of is that of Universal Ranges. This splendidly bound book of sixty pages is a wow. The first thirty-five pages are devoted to sales information that carries a punch while the remaining pages contain illustrations of the line together with "specs." of the various models. It's a job well done in the way of combining two potent sales tools.*

*And speaking of sales helps, reminds us that the John Wood folks have produced a gas water heater sales plan that they have dubbed the "Big Apple Campaign" a good idea that ties in with a popular theme of the moment and like any plan if carried out should prove potent in the matter of getting enthusiasm into the selling force.*

*"Give Gas Glamor" is a tie-in piece produced by A.G.A. to provide ideas for getting localized interest in the gas kitchen idea by staging a showing with the motion picture "Merrily We Live" starring Constance Bennett—look into it, facts may be had as to local showing from your home town theatre and suggestion for tie-ins from A.G.A. headquarters.*



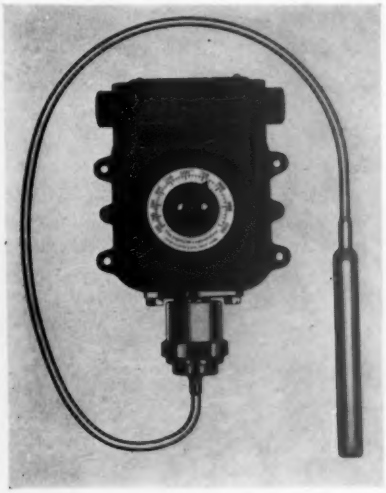
Let an AUTOMATIC GAS RANGE
Cook Chef-style Meals in Your Home
MODERN COOKERY ... CONSTANT HOT WATER SILENT REFRIGERATION GAS HEATING
THE PEOPLES GAS LIGHT AND COKE COMPANY

*Peoples Gas Light and Coke Company, Chicago have been using some pointed paragraphs and pictures in putting over the desirability and preference of gas cookery in news paper advertisements in that city on Lake Michigan recently. As we view them they are very effective.*

# New Equipment

### New Partlow Temperature Control

The Partlow Model Z electric temperature control recently announced is shown in the adjoining cut. It is made in both calibrated and uncalibrated models with three temperature ranges of 350°, 650° and 1000°F. and is regularly supplied with a thermostatic element having a capillary length of 5 feet but longer lengths can be furnished.



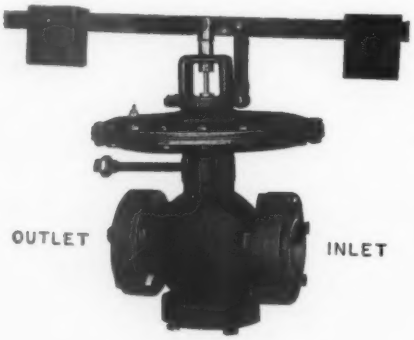
Particularly adapted for baking ovens, air heaters, plastic molding presses, soft metal melting pots and similar devices.

It is equipped with micro switch with either normally closed, normally open or single pole—double throw contacts. Entire cover (front and sides) may be removed for inspection without disturbing the temperature setting or wiring.

Full description with prices in Bulletin 505, The Partlow Corporation, New Hartford, N. Y.

### Fulton Regulator

This regulator, although originally designed for use in Illuminating Gas systems, has today found many fields of application.




It is designed especially for the reduction of an extremely low inlet pressure and is recommended for use where the difference between inlet and outlet pressures is very slight. For many years it has proved to be an excellent District Governor and of late has also found favor in the Industrial field. It will be found regulating the gas pressure to kilns, annealing and heat treating furnaces and in the manufacture of glass.

The Weighted Illuminating Regulator is extremely sensitive due to the absence of stuffing boxes and the use of a large flexible diaphragm.

Further details in Chaplin-Fulton Mfg. Co. 1938 catalog, address 40 Penn Ave., Pittsburgh, Pa.

### Automatic Pilot Control

The "Thermopilot," a new automatic pilot control, is announced by the manufacturers, the General Controls Company. This new control utilizes the performance-proved thermocouple principle of operation. When the flame is applied to the thermocouple element, contact is made, allowing the main gas valve to open. Should the pilot light fail, the "Thermopilot" automatically opens the circuit and the gas valve closes — automatically resets itself when the pilot is relighted.

The thermocouple tube is very flexible for easy installation. Two or three-wire control. Complete information may be had from General Controls Co., 450 East Ohio Street, Chicago, Illinois.

### Duff-Norton Pipe Pulling and Pushing Jacks

A number of important time and labor saving advantages in the laying of pipe lines are afforded through the use of a new Duff-Norton Pipe Pulling and Pushing Jack recently placed on the market.

Designed primarily for pulling and pushing without changing the position of the Jack, this new geared type Duff-Norton unit is capable of forcing pipe up to six inches in diameter. The tearing up of lawns, streets and highways is obviated by its use.

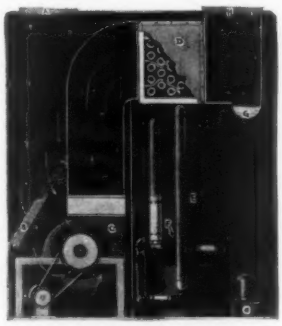
An invaluable aid to contractors, plumbers, public utility and oil companies, municipal and railroad construction projects.

Descriptive literature on this and other products of the company may be had by writing for bulletin 120 issued by the Duff-Norton Manufacturing Company, 2709 Preble Avenue, Pittsburgh, Pa.

# and Appliances

### Sav-T-Heat Air Conditioner

This warm air system consists of a generator (which replaces the boiler or furnace), a heat exchanger, an exhauster, air vent, filter, humidifier, all housed within a streamlined housing, finished in grey, orange, and a stainless steel trim.



In the diagrammed illustration herewith the generator (E), replaces the conventional boiler or furnace. Combustion of gas takes place in the generator and the product of this combustion is drawn by the exhauster into a chamber where the hot gases are mixed with water to form a gas vapor. This vapor contains practically the same Btu content as the hot gases, but is much cooler. The gas vapor travels into the copper heat exchanger (D), where it delivers practically all of its heat. The cooled gases, after leaving the heat exchanger, are vented to atmosphere. Efficiencies of 90 per cent and more are claimed for this new system.

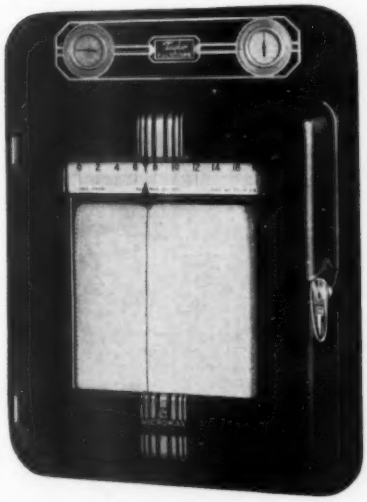
The unheated air which is to be conditioned, enters the Unit at point (A), travels through filters (B) and fans at (C) and is directed through the heat exchanger (E) into the ducts of the system. But before thus passing into the system, the moisture content is regulated at point (G) by a balanced damper.

Booklet describing this system may be had by addressing C. A. Dunham Company, 450 E. Ohio Street, Chicago.

### Air-Operated Potentiometer Controller

For those process control problems where smooth, proportional valve action is imperative and the potentiometer principle of temperature measurement is preferred, the Taylor Instrument Companies, Rochester, New York now offer the Fulscope Micromax Air-operated Potentiometer Controller.

The temperature measuring system is the well known Micromax recording and indicating potentiometer. This is the only potentiometer in which all functions affecting accuracy of temperature measurement are fully automatic — automatic reference-junction compensation; automatic, positive balancing of the potentiometer circuits; and automatic current standardization.



The Fulscope Control Unit operates in conjunction with the Taylor Motosteel Diaphragm Valve. Where precision valve action, or both precision valve action and compensation for changes in load may be necessary to prevent deviation from the control point, the Fulscope control mechanism can be supplemented with the Taylor Valv-Precisor or Dubl-Response Control Unit, respectively. Thus, control equipment which most economically solves the individual control problem may be selected.

### New Pocket Size $CO_2$ Analyzer

The new Dwyer Pocket $CO_2$ Indicator constitutes a radical advance in the instrument field. It is the first indicator on the market that can be safely carried in the coat pocket, but in spite of its small size, accuracy and ease of operation have not been sacrificed. The Indicator, complete with carrying case and all accessories, weighs less than three pounds.

Sales and installation men who like to travel light will find this Indicator most convenient. It will be a valuable addition to any boiler room for direct testing of furnace adjustments, and for checking $CO_2$ recorders for accuracy.

The operation of the Indicator is

very simple, and accurate results are obtained even in the hands of an inexperienced operator. Tests are made while the Indicator is held in the hand or in the clip which is provided in the carrying case. The gas sample is pumped in with a dozen strokes of the aspirator bulb while a plunger is held down. The reading is then taken from the mercury column after the absorbing unit has been raised and lowered.

The body of the instrument is made from a new product of the plastics industry that offers numerous advantages over other materials. The material is perfectly clear and colorless, and unaffected by the caustic solution used in the Indicator. This is not a molded product, but cut from a solid block with all the bores drilled and accurately reamed to size. One important point that is quickly noted is the entire absence of glass.

Complete description in circular issued by F. W. Dwyer Mfg. Co., 565 W. Washington Blvd., Chicago.

## History of the Columbia System is Published

"Columbia System—A History" is the title of a recently published 176 page book by Albert F. Dawson.

Written to commemorate the twenty-fifth anniversary of the taking over of control by the present management, the book covers in considerable detail the history of the Columbia Gas & Electric Corporation.

The first two chapters are devoted to the early discoveries and attempts to utilize natural gas in this country. "The business of capturing natural gas and marketing it on a dependable basis was slow in developing. At the turn of the century the industry had just begun to toddle. The approximate value of natural gas produced and sold in 1900 in the three Appalachian States of largest production was over fifteen million dollars—ten million dollars in Pennsylvania, three million dollars in West Virginia, and a little over two million dollars in Ohio." Compare this with revenues received by natural gas utilities of over 440 million dollars in 1937.

The remaining twelve chapters are devoted to a detailed history of the Columbia System, which has come to be one of our foremost utility companies. One paragraph in Chapter IX is of particular interest. "In many ways it (the Columbia System) was unique among the large companies operating in the public utility field. While its service covered a vast area in five states, the system was a solid block comprising adjacent properties, all inter-connected and inter-dependent. For fifteen years Columbia had adhered to a definite policy in acquiring property. It had never been interested in obtaining geographically separated properties which could not become a co-ordinated part of the system. Without exception every company and property acquired, if not physically connected with the System, was so situated that it readily fitted in and, in fact, was promptly connected by the construction of appropriate transmission lines."

In conclusion the author states: "The quarter-century mark in the history of Columbia System under continuous management policies found this public service organization holding true to its charted course. Its growth and progress were reflected from the figures on its books. In 1912 the Company owned one hundred and twelve gas wells; at the close of 1937 the number was approximately nine thousand. In 1912 it sold less than thirteen billion cubic feet of natural gas; in the last calendar year gas sales were above one hundred and forty-seven billion cubic feet. There were a little more than one hundred fourteen thousand gas customers in 1912; now there are over one million one hundred thousand."

## New Industrial Gas Installations at Portland, Oregon

Lacking a basement or suitable floor space, the Portland Dock Commission faced a problem of where to install an air conditioning unit for a 5-room office at Terminal No. 1, Portland, Oregon. An automatic gas furnace, fan and filter, mounted in the loft, provided the answer.

Sawdust makes the smoke, but gas is what ignites it and automatically maintains the proper temperature in a new smoke-house installed at the Lincoln Kosher Market, Portland, Oregon. Gas was considered the ideal fuel for the installation.

Where thousands of chicks are hatched every year, heat must be as clean as it is constant. That's why the Lloyd Lee Hatchery, Portland, Oregon, continued to favor gas when adding to its heating equipment this season. Gas is used in heating incubators, brooders and buildings.

These installations were made with the cooperation of the Industrial Dept. of the Portland Gas & Coke Co.

*All sizes up to 3,400 cu. ft. capacity*

Meters
Diaphragms
Repairs
Provers
Pumps
Calorimeters
Wet Meters
Gauges
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**METER REPAIR PARTS**
*FOR*
*ALL MAKES — ALL SIZES OF METERS*

LARGEST GAS COMPANIES NOW
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*SEND FOR OUR CIRCULAR ON METER REPAIR PARTS*

SAMPLES AND PRICES
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LAMBERT METER CO.
BUSH TERM. BLDG. 4, BROOKLYN, N. Y.

SAVE

LESS OXIDE removes MORE $H_2S$!

The savings LAVINO "ACTIVATED" OXIDE can make for you are easy to understand: Greater capacity and activity permit far greater $H_2S$ removal per pound of oxide. It's a proven fact.

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*The*
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Highest $H_2S$ removal combined with complete removal of traces. Physical structure insures very low box back pressures.

*THE RECOGNIZED PURIFYING MATERIAL FOR VAPOR PHASE GUM CONTROL.*

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**192 FRONT ST., NEW YORK**
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# HEATING BUNKER "C" OIL

for carburetting gas requires high pressure and high temperature.

# ANDALE BOWED TUBE HEATERS

remain tight and are easily cleaned. These are the requirements for continuous satisfactory operation.

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# SUPERIOR

Diaphragms
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Gas Meters

## SUPERIOR METER CO.

Brooklyn, N. Y.
167-41st Street

# News of the Industry

## Pennsylvania Gas Association Annual Convention at Skytop, Pa.

The annual convention of the Pennsylvania Gas Association was held at the Skytop Lodge, Skytop, Pa., on May 3, 4 and 5. Papers were devoted to the distribution, accounting, customer and employee relations, production and new business problems of the industry.

The convention opened with the annual banquet on May 3. Following a short business session Howard S. Christman, president of the state association, delivered his address.

The session on May 4 was taken up with distribution, accounting, and customer and employee relations matters, with C. C. Jones, E. N. Keller, and H. H. Ganser, respectively, presiding. R. J. Ott, The Philadelphia Gas Works Company, spoke of "Noisy Meters," J. W. Buxton, Philadelphia Electric Company, discussed "Experience with Leak Locator and M-Scope."

E. N. Keller, Philadelphia Electric Company, presented the "Report of the Pennsylvania Gas Association Accounting Committee," while "Departmental Responsibilities in Connection with Uniform System of Accounts" was the topic of M. H. Parkinson, Pennsylvania Power & Light Company, A. A. Nicholson, The Texas Company, New York, talked on "Better Customer Relations—Better Men—Better Business," and the morning session closed with "Customer Relations—Progress Report," by Blackwell Newhall, The Philadelphia Gas Works Company.

The closing day, May 5 was devoted to a session on production and new business problems, with R. G. Rincliffe and A. M. Wiley, respectively, presiding. Following the paper on "Control of Holder Discoloration," by Dr. J. R. Skeen, United Gas Improvement Company. Harold P. Mueller, Philadelphia, offered as his topic "A Builder Speaks to the Gas Industry."

Two interesting papers, "Gas Grows Up With the Country," by H. G. Schaul, West Chester Lighting Company, Mount Vernon, N. Y., and "We've Got What It Takes," by Carl Randall, Pennsylvania Power & Light Company, Allentown, Pa., followed. The closing paper was on "Modern Cooking," by E. C. Sorby, George D. Roper Corp., Rockford, Ill."

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A tentative program for the meeting of Indiana Gas Association which is to be held at Hotel Gary, Gary, Ind., on May 15th to 17th, has been issued. Through the constructive activities of Commercial, Technical and Accounting Committees, the indications are that the convention will be the best attended by far of any in the Association's history.

Copies of the program may be secured through P. A. McLeod, Secretary-Treas- of the Association at New Castle, Ind.

### CONVENTION CALENDAR

**May**

9-12 *A.G.A. Natural Gas Department,* Roosevelt Hotel, New Orleans, La.

14-21 *International Petroleum Exposition,* Tulsa, Okla.

16-17 *Indiana Gas Association,* Annual Convention, Hotel Gary, Gary, Ind.

18-19 *New York-New Jersey Regional Gas Sales Conference,* Hotel New Yorker, New York.

23-24 *A.G.A. Commercial and Hotel & Restaurant Sales Conference,* New York, N. Y.

24-26 *A.G.A. Production & Chemical Conference,* Hotel Pennsylvania, New York.

25-28 *A.G.A.E.M.* Annual Convention, White Sulphur Springs, W. Virginia.

**June**

9-10 *Canadian Gas Association,* Annual Convention, Royal York Hotel, Toronto. (No exhibits.) G. W. Allen, Secretary - Treasurer, Astley Avenue, Toronto, 5.

16-17 *Pacific Coast Gas Association.* Northwest Conference, Portland, Oregon.

23-24 *New England Gas Association,* Sales Conference, Viking Hotel, Newport, R. I.

**September**

14-16 *Pacific Coast Gas Association,* Annual Convention, Santa Barbara, Calif.

**October**

10-14 *American Gas Association,* Annual Convention, Atlantic City. (No exhibits.)

## The Annual Convention of the A.G.A.E.M.

The important part the Association of Gas Appliance and Equipment Manufacturers is playing in the life and growth of the American gas industry, its contributions to the nation as a whole both in human and economic values, and the rapid strides which are being taken in attaining its objectives will be extensively reviewed at the Association's annual convention beginning May 25th at White Sulphur Springs.

One of the entertainment attractions during the convention will be the golf tournament which has been arranged by a committee under the chairmanship of E. R. Guyer, vice-president of Cribben & Sexton, of Chicago.

Representative Bruce Barton, of New York, who, through his one-man campaign to "repeal ineffective and obsolete laws" is receiving nation-wide attention, will be a chief speaker at the closing general session. Known as a brilliant and informative speaker, Mr. Barton's participation in the convention is being looked forward to by the many expecting to attend.

Following the opening address by President Davis welcoming the members of the Association and their invited guests to the annual convention, N. C. McGowen, president of the American Gas Association, will describe the co-operative relationship which exists between the two Associations and how together they are promoting the industry and increasing the distribution and sale of gas and gas appliances.

Other speakers will be C. W. Berghorn, managing director of A.G.A.E.M., Major Alexander Forward, managing director of the A.G.A., Hugh H. Cuthrell, president of Gas Exhibits Inc., Bruce A. Wilson, R. G. Logue, F. E. Sellman, H. N. Ramsey, H. P. Mueller and W. E. Derwent.

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## New England Gas Association Industrial Division Meeting

At Hotel Puritan, Boston, the Industrial Division of New England Gas Association held a meeting at noon on April 22nd. Following the opening remarks of George S. Hawley, president of the Association and of the Bridgeport Gas Light Company, the following subjects were presented: "Are You Selling Commercial Gas Refrigeration?" by Carl Conkey of Servel Inc., which was replied to in the affirmative by J. F. Quinn of Brooklyn Union Gas Co. L. B. Crossman of Boston Consolidated Gas Co. spoke on "New Developments in Counter Cooking Equipment." Following the meeting, opportunity was afforded to visit the Division's gas appliance exhibit at the New England Hotel Exposition at the Hotel Statler.

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## N. Y.-N. J. Regional Gas Sales Conference

Sponsored by the Commercial Section of American Gas Association, the New York-New Jersey Regional Gas Sales Conference under the chairmanship of William J. Schmidt of Long Island Lighting Co. will be held May 18 and 19 at Hotel New Yorker, New York.

Following Mr. Schmidt's opening ad-

dress on sales opportunities for gas men in the New York-New Jersey area there will be an interesting and instructive program on sales promotion and methods delivered by well-informed speakers. Customer Relations, The Gas Industry at the World's Fair, The Certified Performance Range and a skit on how water heaters should and should not be sold are included in the program.

### Hotel, Restaurant and Commercial Sales Conference

On May 23rd and 24th, the American Gas Association Hotel, Restaurant and Commercial Sales Conference will be held at Hotel Commodore in New York instead of the Belmont Plaza as previously announced. This meeting, sponsored by Industrial Gas Section of A.G.A. and Metropolitan Industrial Gas Sales Council, contemplates a program of unusual interest. Among the topics to be presented are "Getting 100 Cents of the Cooking Dollar," "Selling Complete Gas Service to Commercial Customers," "What's New in Commercial Gas Appliances," "How a Customer Evaluates Commercial Gas Cooking" and "Selling Gas Equipment to a Barber."

Additional punch will feature the meeting through the luncheon speaker Zenn Kaufman, a sales authority of national reputation. Franklin T. Rainey of Ohio Fuel Gas Company is Chairman of the Committee on Program and Arrangements.

**Entries Roll in for Architects Competition**

Center—Major Alexander Forward, Managing Director of the American Gas Association—right—J. F. Quinlan, Director of the Home Appliance Planning Bureau and left—F. W. Williams, Assistant to Director, Home Appliance Planning Bureau, examining hundreds of entries already received in the nationwide American Gas Association Architects' Competition.

### Annual Home Service Conference

The second annual Home Service Conference and Training Course will be held in Kansas City, Mo., June 7, 8, 9 and 10. All meetings will be held at the Hotel Muehlebach.

The course is sponsored by the Home Service Committee of the American Gas Association, whose chairman this year is Mildred Clark of the Oklahoma Natural Gas Company. In the first course, held last summer at the A.G.A. Testing Laboratories in Cleveland, an attendance of 175 was made up of home service directors as well as teachers and students from Colleges of Home Economics. This year also invitations are being extended to all colleges so that students interested in entering the field of home service can gain at first hand a knowledge of the nature of that work.

The four-day course will include a study of actual demonstrations, skits portraying different types of work, and practical instruction in the use and care of gas equipment.

Group from Downtown (N. Y.) Gas Engineers Lunch Club wishes Erick Larson luck as he leaves to take up new duties as assistant to Alfred Hurlburt, Vice President, Republic Natural Gas Co., Corpus Christi, Texas. Mr. Larson has been in the engineering department of the Long Island Lighting Company for the past fourteen years. He is a past chairman of the Distribution Committee of the American Gas Association's Technical Section.

**Front Row** (L. to R.) Floyd W. Parsons ("Gas Age"); Erick Larson; W. P. Hutchinson (Sprague Meter Company).

**Center Row** (L. to R.) G. H. Magee (Long Island Lighting Company); T. B. Williams (Utility Management Corporation); A. E. Lockwood (Penn-Western Service Corporation); E. J. Murphy (Brooklyn Union Gas Company).

**Back Row** (L. to R.) J. R. Wohrley (Cities Service Company); Stanley Jenks ("Gas"); A. I. Phillips ("American Gas Journal"); A. Gordon King (American Gas Association).—

### "Penny's Party" A.G.A. Launches a Short in Technicolor

Again the A.G.A. offers gas companies an opportunity to tie in with appropriate advertising copy mats and leaflets to be used at the time when "Penny's Party," a fast moving ten minute short in technicolor is being shown in the local theatres. This picture which won the Academy Award for "The Best Short Subject of 1937" is a sequel to "Penny Wisdom," recently released. Nearly all the action is staged in a smart all-gas kitchen and has unusual feminine appeal. In a bulletin the A.G.A. recommends five ways to tie-up and cash-in on the picture.

## Charles A. Munroe Award

Presentation of the Charles A. Munroe Award, one of the highest honors bestowed by the gas industry, will be made at the annual convention of the American Gas Association in Atlantic City, N. J., next October. The award consists of a substantial sum of money and a permanent certificate. It is made annually by the Association to the individual judged to have made the most outstanding contribution toward the advancement of the gas industry.

The accomplishment may be along any line. Since the first award in 1929, it has been given for developments in refrigeration, labor saving accounting, rate making, dealer cooperation, sales expansion, public relations, research and change-over from one to another kind of gas. It has been won by a distinguished group of individuals.

Addison B. Day, chairman of the board, Southern California Gas Company, is chairman of the 1938 committee which will judge the applications submitted. Other members of the committee are: George H. Clifford, president, Stone & Webster Service Corporation, and E. M. Farnsworth, president, Boston Consolidated Gas Company.

Companies employing individuals who are deemed worthy of consideration for the award are urged to sponsor applications in their behalf. All applications for the 1938 award should be filed with the American Gas Association, 420 Lexington Ave., New York City, before August 1, 1938.

INDUSTRIAL GAS BOILERS

Tubular or Flueless
¾ to 45 H.P.

P. M. LATTNER MFG. COMPANY
CEDAR RAPIDS, IOWA

## New York World's Fair 1939 Celebrates with Imposing Preview

A pageant long to be remembered which gave a foretaste of what may be expected of the 1939 New York World's Fair was the preview held in New York on April 30th.

A Motorcade with approximately 300 floats and many other vehicles paraded through Manhattan and proceeded to the Fair site.

Representing business and industry both local and national the floats included one of Gas Exhibits Incorporated and one of Consolidated Edison Co. Some floats were colorful models of the entrant's exhibit at the coming Fair.

From Queens Borough a parade of some 200,000 marchers with many bands also converged on the Fair site where a six-hour program of ceremonies and entertainment features followed, including a world-wide broadcast from the grounds. This fore-runner, a year in advance of the opening date, was planned to focus national and international attention on the 1939 Fair.

## Gas Exhibits at New York World's Fair

Leading manufacturers of gas appliances and equipment from all parts of the United States have already taken space in the main exhibit area of the gas industry's exposition group at the New York 1939 World's Fair, it was announced by Hugh H. Cuthrell, president of Gas Exhibits, Inc., from the national headquarters in New York City.

It was disclosed that all gas appliances exhibited in its buildings will be shown in surroundings identical to those they would have if they were in actual use. Devices used in kitchens will be displayed in modern kitchen settings; water heating, house heating, and air-conditioning mechanisms will be in operation in locations typical of where they are usually placed.

In a model "all-gas house" which will stand in a tree-shaded patio, visitors will be able to view in actual working conditions the various applications of gas in the home. Modern, efficient types of gas appliances for cooking, refrigeration, space and water heating, and air-conditioning will be displayed there.

Among the manufacturing companies to display their products in the gas industry's exhibit group at the Fair will be

American Gas Products Corp., American Stove Company, Cleveland Heater Company, Cribben & Sexton Company, General Gas Light Company, Roberts & Mandor Stove Company, Robertshaw Thermostat Company, Geo. D. Roper Corporation, Servel, Incorporated, Surface Combustion Corporation, Tappan Stove Company, Welsbach Company, Detroit-Michigan Stove Company, Estate Stove Company, Glenwood Range Company, Ruud Manufacturing Company.

It is planned to make the gas industry's exhibit among the outstanding features at next year's international event. Nationwide interest has been centered on the spectacular "Court of Flame," the focal point and main entranceway to the exhibit group.

## Gas Industry Exhibit for Western World's Fair

New efficiencies in the domestic use of gas will be demonstrated at the Golden Gate International Exposition in 1939 by the Pacific Coast Gas Association, which has contracted for more than six thousand square feet of floor space in the Homes and Gardens building of the Western World's Fair.

Treasure Island, the Exposition site, will be serviced with gas through a submarine pipeline under San Francisco Bay, and the gas exhibit will bring out every economy of this natural fuel. Details are being worked out by a committee representing the utility and appliance-manufacturing branches of the industry, according to Clifford Johnstone, secretary-manager of the Association.

Principal sponsors, through the Association, are the Pacific Gas & Electric Company, Southern California Gas Company, Southern Counties Gas Company, Santa Maria Gas Company, Coast Counties Gas & Electric Company and San Joaquin Light & Power Corporation. Gas companies throughout the country are being invited to participate.

R. E. Fisher, vice president in charge of sales for P. G. & E., is committee chairman. Other committeemen are H. L. Farrar, president of Coast Counties; R. A. Hornby, vice president of Pacific Lighting Corporation; C. R. Graham of Jas. Graham Manufacturing Company, chairman of the Association's Manufacturers' section; H. R. Basford, president of H. R. Basford Company, and Don Fleming, San Francisco manager for Payne Furnace and Supply Company.

## Charles H. Bliss New President American Utilities Service Corp'n.

Charles H. Bliss has been elected president of American Utilities Service Corporation, 327 So. LaSalle St., Chicago, succeeding Perry Crawford who has resigned to become vice president of Central Service Corporation, both positions effective May 1, 1938.

### Servel Again Sponsors "March of Time" Broadcast

This year's premier presentation of the "March of Time" radio program under the sponsorship of Servel, Inc., took place on Thursday, April 7, in the presence of a studio audience of more than a hundred persons who were the guests of George S. Jones, Jr., vice-president and general sales manager of the company, who made the trip to New York especially to attend the broadcast. This is the second consecutive year in which Servel, Inc., has sponsored the "March of Time" during the Spring and Summer refrigerator selling season.

**Sound Effects Demonstrated for Servel Officials.**

**At the conclusion of the presentation, officials of Servel, Inc., learned from the operator how sound effects are made. In the above picture, the sound effects man is shown at the left. Next to him is George S. Jones, Jr., vice-president and general sales manager of Servel, Inc. B. O. Brown, regional sales manager, at the right, also shows keen interest in the demonstration.**

A feature of the "premier" presentation was an informal gathering of Servel officials in the studio at the conclusion of the broadcast, who met the members of the cast and the directors of the program. Among these Servel executives, besides Mr. Jones, were F. E. Sellman, vice-president of Servel; B. O. Brown, regional sales manager; William Reynolds, advertising manager; A. E. Lee, assistant to Mr. Jones, and Jane Tiffany Wagner, director of the Servel home service department. Present both at the broadcast and at the informal gathering afterward were F. R. Feland, Edward Hosp, and Leroy H. Dreher, members of the staff of Batten, Barton, Durstine and Osborne, one of the leading advertising agencies in the country, under whose auspices the "March of Time" program is sponsored by Servel.

Great interest was shown by the studio audience in the way in which the presentation is made by the large group of actors who take part in the performance. So well done are the impersonations of leading personalities in current history, through simulation of their voices and gestures, that all the important news of the world is brought to the fireside with much skill and realism.

High praise was given for the clear, concise and graphic manner in which the "commercial portion" of the program was presented. This brief talk told listeners about the "refrigerator which you hear about but never hear."

## Catalogs

**Regulators.** A comprehensive line of regulator equipment is described in the new 1938 gas regulator catalog issued by Chaplin-Fulton Manufacturing Company, 40 Penn Ave., Pittsburgh, Pa. The catalog includes also several pages of tabular information of value to field men and engineering departments giving general dimensions of iron, bronze and steel body high pressure regulators as well as dimensions of those designed for low and medium pressures. Copy of this 76 page catalog sent on request.

**Centrifugal Pumps.** Cameron two-stage centrifugal pumps, their characteristics, details and applications are described in Bulletin 7067 issued by Ingersoll-Rand, 11 Broadway, New York.

**Pipe Tools.** Beaver Pipe Tools are shown and described in some detail in two recent bulletins issued by Beaver Pipe Tools, Inc., Warren, Ohio.

**Pipe Line Thermometers.** "Anti-Ambi" recording thermometers described in folder 742 of The Foxboro Company, Foxboro, Mass., give written temperature records of gas in pipe lines. Ambient temperatures, barometric pressure or bulb elevation do not affect accurate record.

**Arc Welder.** "Shield-Arc SAE" welder, type S-6037 is shown in folder 327 of Lincoln Electric Co., Cleveland, Ohio.


# The Life of Trade

*(Do you need half a million bushels of oxide today?)*

"COOPERATION *and not competition is the life of trade.*" A true maxim! And to realize it, G. P. M. keeps on hand the largest ready-to-use stock of iron oxide in the world (more than 600,000 bushels) so that the simultaneous emergency calls of several gas plants may be instantly satisfied.

**Gas Purifying Materials Co. Inc.**

*L. I. City, N. Y. & Providence, R. I.*

GPM IRON HYDROXIDE

# Food For Thought

**1. 20,000 miles of mains surveyed.**

**2. 14,000 new gas leaks located.**

**3. 40,000 valuable reports made on trees and shrubs.**

**4. 150 companies using the service.**

**5. Enough savings in unaccounted for gas to pay the bill.**

**6. A trial will convince you.**

***May we hear from you?***

**New England Forestry Service Inc.**

**75 Federal St., Boston, Mass.**

"I Never Liked that Girl
...but somehow lately she's Changed!"
"She used to come to work looking like a dishrag. Always tired lifeless . . half asleep. She seemed careless about her appearance. Just when I was about to fire her, she suddenly changed. Like that!
"Look at her now—fresh . . . alert . . . pretty as a picture. And how she turns out the work! I'm going to make her my private secretary."
Would it surprise you to know that hot water worked this miracle? A good bath every morning does wonders for anyone. It wakes you up . . . makes you fresh, alert, alive. Keeps you clean and smart-looking. So you feel more confident . . more capable. There's health in hot water. And beauty, too! So use plenty of it. You can—if you have automatic water heating by gas. Then hot water is a blessing—not a burden. For there's no work, no waiting, no dust, dirt, coal or ashes. Just dependable hot water service day or night—always ready—as much as you need.
For as little as $3 DOWN
you can have the convenience and comfort of automatic water heating by gas. Monthly payments are very small and there's no charge for installation! Just phone RITtenhouse 5100, or visit one of the show-rooms below.
Use GAS FOR THE 4 BIG JOBS
COOKING
REFRIGERATION
WATER HEATING
HOUSE HEATING
THE PHILADELPHIA GAS WORKS COMPANY
BROAD AND ARCH STREETS

Original 4 Col., 12¾ in. high

## Lefton Advertisement Wins "Socrates Award"

The "Socrates Award" for the best ad of the month in a competition run by Vincent Edwards in their "Public Utility Adviews" of March 1938 is entitled, "I Never Liked that Girl," and is shown herewith.

In the opinion of the judges "this advertisement approaches the 'social stigma' problem with care, handling the subject with such finesse that the familiar theme becomes not only fresh, but logical and believable. Selling gas water heaters as providing the tonic that women office workers need in order to keep alert and attractive, does two things: (a) opens a new avenue of sales possibilities; (b) smartly varies the threat-of-social-ostracism theme that has been freely used by national advertisers.

"The headlines telegraph the story instantly, providing a powerful attention-stopper that no woman will pass by. And using photographs of two mature, dignified executives is good psychology; this treatment creates an office atmosphere and also registers the idea that the office worker is closely scrutinized by the man for whom she works.

"The two opening paragraphs of conversational-copy are written simply and directly, and the closing paragraph sells hot water—and gas water heaters—as an inexpensive, always-available tonic that insures energy and thus contributes to a smart, well-groomed appearance.

"The entire piece is kept clean-cut, crisp and vigorous. The bold headline pulls the eyes down through the photograph and into the copy; the tailored copy blocks and adequate areas of white space are well handled, and sketched figure of a secretary at her typewriter, rounds out the office feeling."

This advertisement and three others which won "points" in the same competition were submitted by Al Paul Lefton Company of Philadelphia.

## New Jersey Gas Association Meets

The Twenty-seventh Annual Meeting of the New Jersey Gas Association was held on April 12th at the Berkeley-Carteret Hotel, Asbury Park, N. J. An attendance of approximately 800 is indicative of the interest shown in it.

The members and guests were welcomed by Mr. T. R. Crumley, President of Jersey Central Power and Light Company. Thereafter Mr. J. P. Leinroth made his Presidential Address and Major Alexander Forward presented "Greetings from A.G.A. Headquarters."

An important feature of the morning session was a paper on the economic situation of the gas industry, prepared by Mr. Walter C. Beckjord, Vice President of Columbia Gas & Electric Corporation and read in his absence by Mr. Irving K. Peck, President of Binghamton Gas Works.

A symposium on "Employee Cooperative Efforts" was presented by John E. Baumgarten, Public Service Electric and Gas Co., John J. Maloney, Perth Amboy Gas Light Co., Edward Polhemus, Jersey Central Power and Light Co. and A. Valentine Bohn, Public Service Electric and Gas Co.

In the afternoon there were two meetings—a general session and a session sponsored by the Technical Committee for manufacturing and distribution department executives and employees. The programs included papers on Selling Hot Water by Selling Cleanliness, "The Certified Performance Range," "Home Appliance Planning Bureau Activities," "Gas Appliance Servicing" and "Safety First."

## Missouri Association of Public Utilities Annual Convention

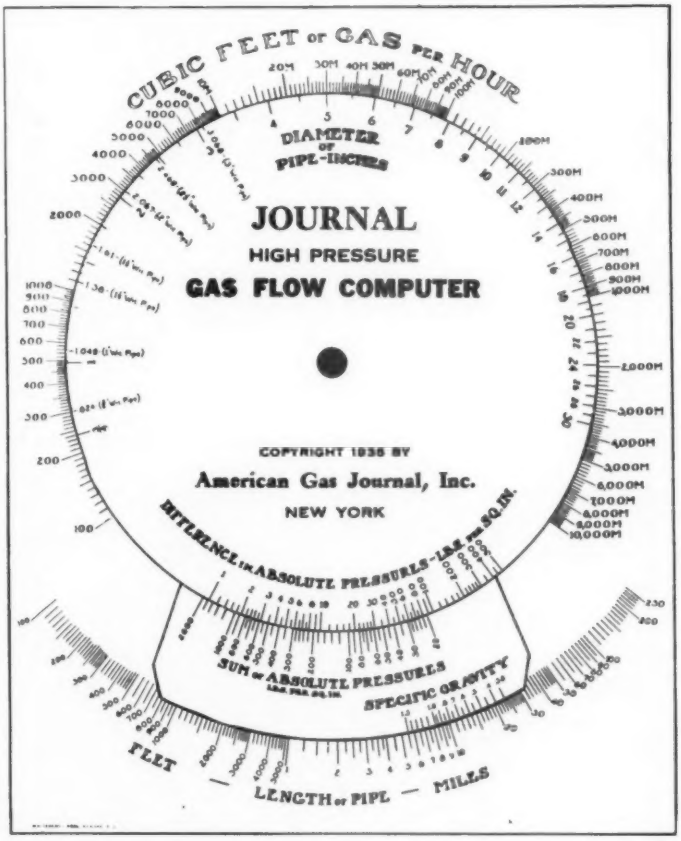
Chester C. Smith, Kansas City, Mo., vice president of the Kansas City Power & Light Company, was re-elected president of the Missouri Association of Public Utilities at its thirty-second annual convention April 20, 21 and 22 in St. Louis, Mo. The Association membership comprises virtually all of the privately-owned electric, gas, water, and transportation companies in Missouri.

The other officers elected were: First vice president, E. H. Lewis, St. Louis County Gas Company, Webster Groves, Mo.; second vice president, Ben C. Adams, Gas Service Company, Kansas City, Mo.; third vice president, O. F. Funk, Union Electric Company of Missouri, St. Louis; treasurer, Hermann Spoehrer, Union Electric Company of Missouri; secretary, N. R. Beagle, Missouri Power & Light Company, Jefferson City, Mo.; assistant secretary, Jesse Blythe, Jefferson City, Mo.; managing director, E. A. Beer, Jefferson City, Mo.

**OFFICERS OF NEW JERSEY GAS ASSOCIATION**

**President—B. A. Seiple, Vice President in Charge of Sales, Jersey Central Power and Light Company.**
**First Vice President—G. B. Webber, Head of Educational Department, Public Service Electric and Gas Company.**
**Second Vice President—F. H. Darlington, Superintendent of Distribution, Peoples Gas Company, Glassboro.**
**Secretary-Treasurer—H. A. Sutton, Public Service Electric and Gas Company.**

# "Journal" Gas Flow Computers




**New Improved Gas Flow Computers now available of durable celluloid, encased in a convenient leatherette cover with complete instructions.**

**Actual Size 6¼ x 7½**

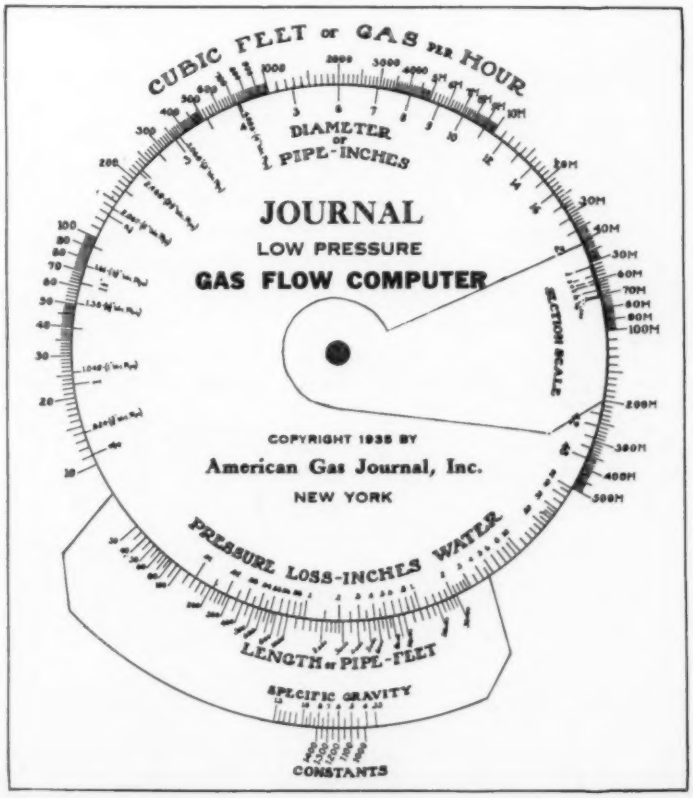
## High Pressure Computer Range:

Cu. Ft. of Gas Per Hour—100-10,000 M
Diameter of Pipe Inches ¾-30
Difference in Absolute Pressure—Lbs. per sq. in. 1-500
Sum of Absolute Pressures—Lbs. per sq. in 2000-20
Specific Gravity 1.5-.35
Length of Pipe—Feet 100-5000
Length of Pipe—Miles 1-250

## Low Pressure Computer Range:

Cu. Ft. of Gas Per Hour—10 to 500 M
Pipe Diameter ¾" to 48" (including standard and actual weight up to 4")
Pressure Loss Inches .01-10.
Length of Pipe—Feet 30-30,000
Specific Gravity 1.5-.35
Constants 1400-1000

**Price $3.50 Each, Postage Prepaid**




AMERICAN GAS JOURNAL
53 Park Place, New York

Please enter our order for Computers as follows at $3.50 each, postage prepaid

....HIGH Pressure Computer

....LOW Pressure Computer

NAME .....

ADDRESS .....

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**IMPROVED EQUIPMENT — RUSSELL ENGINEERING**

Coal Gas Plants—Horizontal Ovens, Benches, Refills, Additions, Repairs, Charging and Discharging Machines

DIVISION OF
COMBUSTION UTILITIES CORPORATION
24 STATE STREET
NEW YORK

Oil Gas Plants—"Refractory Screen" Process for Base—Standby or Peak Loads—On Existing or New Water Gas Sets Low or High B.T.U. Gas

**ISBELL-PORTER COMPANY**

Engineers and Contractors for Complete Gas Works

I-P Co.

Manufacturers of All Kinds of Gas Apparatus

NEWARK, NEW JERSEY

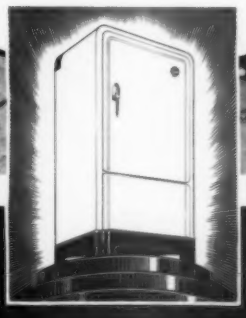

HUGHES PRINTING CO.
EAST STROUDSBURG, PA.

## ONE REASON WHY YOUR CUSTOMERS CAN SAY

*"Our Servel Electrolux runs Perfectly—even on the Hottest Days"*

● Here's the "Hot Room." In this corner of Servel's 35-acre factory, the completed Servel Electrolux unit is tested under a constant temperature of 100 degrees F. The "Hot Room" duplicates in every way the conditions that might exist in your customer's home during the most torrid summer weather.

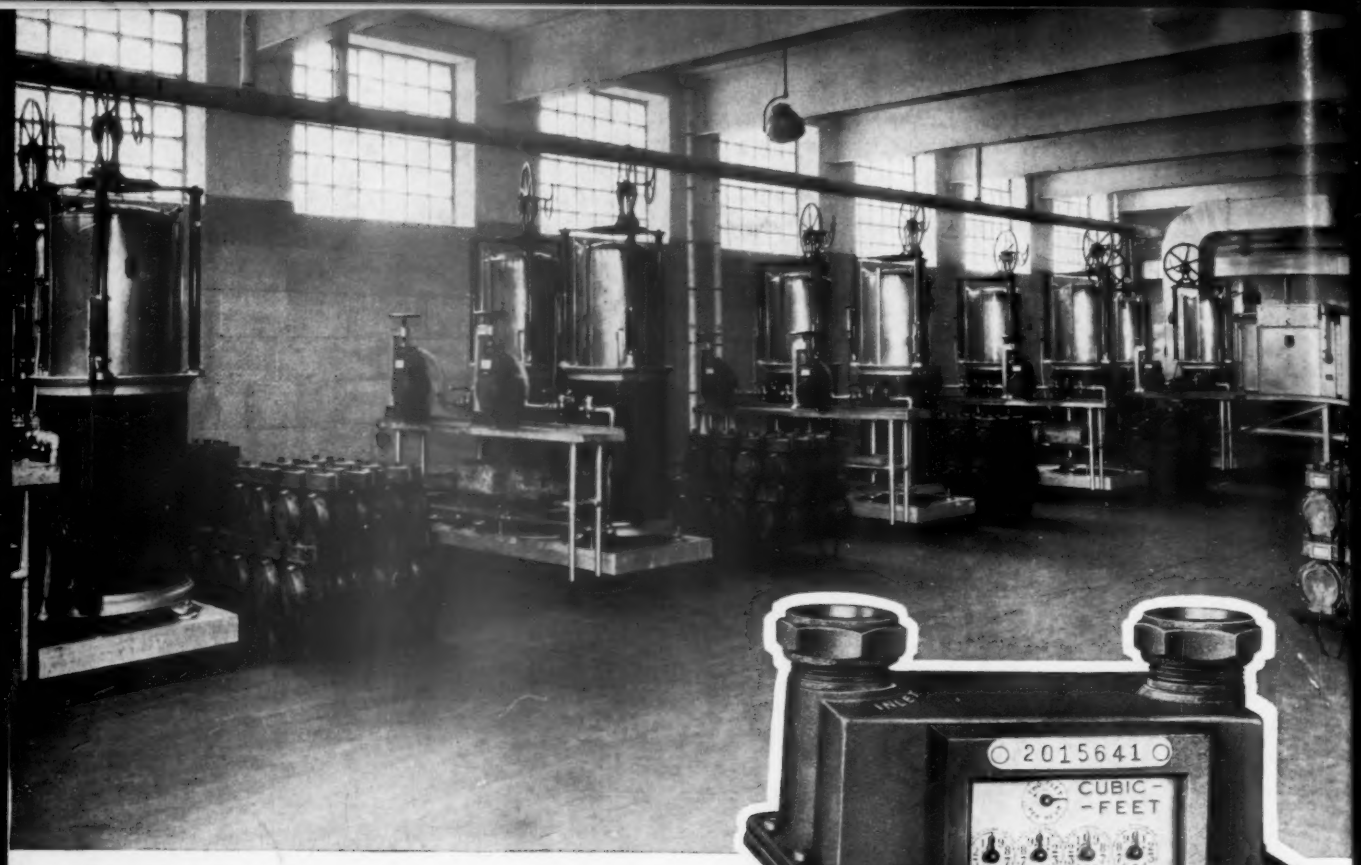
And not until the unit stands up perfectly through this test is a Servel Electrolux allowed to enter that home. Such tests, such care in manufacture, assure that every Servel Electrolux will give lasting efficiency and lasting satisfaction . . . will build goodwill for gas and gas service.



**SERVEL**
**ELECTROLUX**
THE Gas REFRIGERATOR

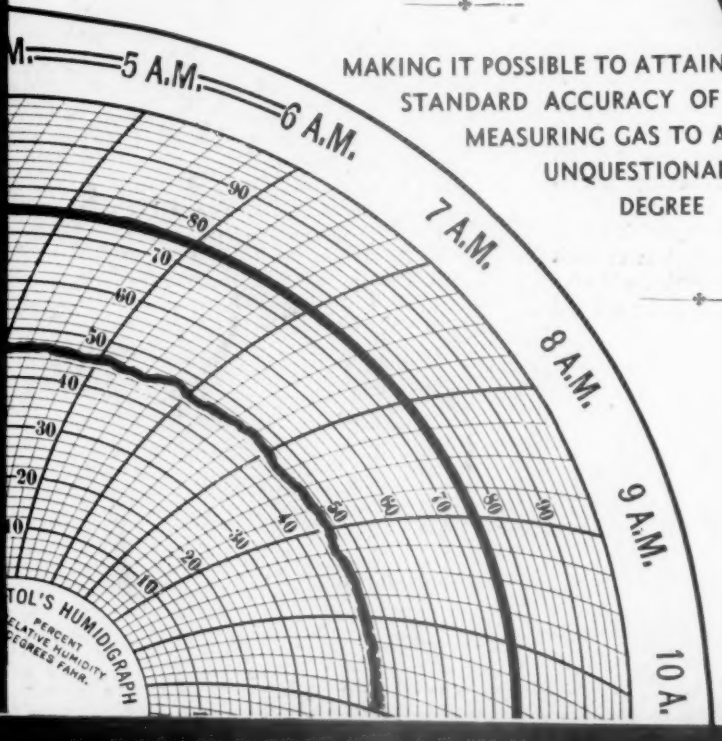
*The Refrigerator Your Customers Hear About . . But Never Hear!*

# Modern Proving of Gas Meters



ALL SPRAGUE METERS ARE TESTED FOR ACCURACY IN A MODERN AIR AND TEMPERATURE CONTROLLED PROVING ROOM

A STEP FORWARD IN ELIMINATING HAZARDS OF CHANCE AND OBTAINING THE ULTIMATE IN UNIFORMITY OF PERFORMANCE




MAKING IT POSSIBLE TO ATTAIN STANDARD ACCURACY OF MEASURING GAS TO AN UNQUESTIONABLE DEGREE

MODERN METERS, BUILT AND PROVED T[HE] MODERN WAY, MAKE FOR DEPENDABILIT[Y] ACCURACY, LONGER LIFE, AND LOWER OPERATING COSTS

HAVE YOU OUR CATALOGUES 16A, 17, 18, 19 AND 20?